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Evaluation of the Maintenance Effect on Fugitive Emissions from Refineries in the South Coast Air Quality Management District

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16. ABSTRACT
The report summarizes results of a data collection investigation of the effectiveness of rules to control volatile organic compound (VOC) fugitive emissions from California's South Coast Air Quality Management District (SCAQMD). A leak detection survey (hydrocarbon detector screening) at two refineries in the SCAQMD and refinery records from previous inspections were reviewed. Other data was collected to evaluate the effect of screening at various distances from the source for pump and compressor seals, and to evaluate seal lifetimes or replacement policies. The leak detection survey in eight process units at the two refineries (for sources subject to the rules) found the following percent leak sources: valves - 5.4%, pump seals - 17.2%, open-ended lines - 4.8%, and other sources - 5.5%. Approximately 15% of the sources could not be screened, primarily due to location. In one refinery, all leaking valves were maintained after the initial screening: they were screened again after maintenance. (Based on emissions estimated from the before and after screenings, valve emissions were reduced by more than 95%.) Records of leak frequency showed unit leak frequencies after initiation of the rules from zero to 12%. Leak recurrence rates (after 3 months) averaged about 8% of the sources repaired. Pump records showed that most seals were replaced every 1 to 1-1/2 years.

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Processing	Seals (Stoppers)	Fugitive Emissions	13H	11A
Leakage		Volatile Organic Compounds	14G	
Maintenance			15E	
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EVALUATION OF THE MAINTENANCE EFFECT ON FUGITIVE EMISSIONS FROM REFINERIES IN THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Final Report

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ABSTRACT

Seven areas of interest were investigated in a screening study coupled with an inspection of maintenance records and a historical review of the effects of previous inspections and maintenance performed under the South Coast Air Quality Management District (SCAQMD) Rule 466.1 in two refineries.

The category of pumps has the highest rate of leaks at 17.2 percent, with all other categories at 5.5 percent or less. Maintenance could reduce emissions 96 to 97 percent. Leak frequency varied from unit to unit and from time to time. Leak recurrence rates after 3 months ranged from zero to 19 percent, with the average being 8 percent of the sources which had been repaired. Readings taken at distances other than zero could be correlated. As a seal aged, it tended to leak a bit more. The mean time between seal replacements was 1.0 to 1.5 years; approximately 90 percent of the seals are replaced within 3 years. Both the quantity involved and the disposition of process samples indicate minimal contribution to fugitive emissions. Less than 20 percent of the observed variation was attributable to the instrument or screening process. A mean screening value of X can be expected to be between X/2.5 and 2.5X for 95 percent of the time.

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SECTION 1

INTRODUCTION

Radian Corporation, under contract to the EPA Industrial Environmental Research Laboratory (Contract No. 68-02-3171-030), has coordinated a program to investigate the effectiveness of regulations pertaining to control of volatile organic compound (VOC) fugitive emissions from petroleum refineries in California's South Coast Air Quality Management District (SCAQMD).

1.1 OBJECTIVES

The following objectives were fulfilled to provide VOC fugitive emission control effectiveness data:

- conduct leak detection surveys (screening) at refineries complying with SCAQMD Rule 466.1,
- evaluate the immediate effects of maintenance on leaking sources,
- obtain screening measurements at several distances from pump and compressor seals and develop correlations between the measurements (screening values) and distances from the source,
- examine records kept by the refineries pertaining to leak detection surveys performed as required by Rule 466.1,
- obtain information (as available) pertaining to pump and compressor seal maintenance history, and
- obtain information (as available) pertaining to process sampling procedures.

1.2 SCOPE OF WORK

The field measurements and historical records used as bases for the results of this program were obtained at two refineries that have been complying with Rule 466.1.[1] The refineries selected for study are the Chevron refinery in El Segundo (tested by Radian Corporation) and the Powerine Oil Company refinery in Santa Fe Springs (tested by GCA Corporation).

The eight process units surveyed in these two refineries are shown in Table 1-1. Two of the process units, alkylation and Isomax hydrocracking, were surveyed on a process subunit basis. In this report, however, subunit results are usually combined into appropriate process unit data sets. Each of three of the process units listed, crude distillation, crude distillation off-gas plant, and platformer, is actually a combination of two parallel units. For this program, results for two parallel units are usually combined into one appropriate process unit data set.

The screening surveys were conducted by two-person teams (one engineer/scientist and one technician per team). The teams screened valves, pumps, compressors, open-ended lines, drains, and relief valves within the eight process units with a portable hydrocarbon detector to identify the sources of fugitive VOC emissions. Procedures specified in EPA Method 21 (presented in Appendix B) were followed during the screening surveys. The hydrocarbon detector used was the Century Systems OVA 108 calibrated with methane, which displays hydrocarbon concentration in parts per million by volume (ppmv). In addition to the maximum hydrocarbon detector reading for each source, certain information describing the source and its process conditions were recorded. This information included the type of process unit, type of source

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[1] Rule 466.1, included in Appendix A, specifies refinery implementation of a leak detection and repair program for valves and flanges in VOC service that meets specific vapor pressure criteria. The regulation specifies inspection, repair, and record keeping procedures. For this report, any fugitive emission source in the vapor pressure range specified in Rule 466.1 is classified as covered by the rule.

TABLE 1-1. REFINERY PROCESS UNITS TESTED

Refinery	Process Units Tested
Chevron	1. Alkylation subunits: - deisobutanization - separator - reactor
	2. Isomax Hydrocracking subunits: - separator - reactor - butane storage
	3. Fluid Catalytic Cracking (FCC) Gas Recovery[a]
	4. FCC Reactor[b]
Powerine	5. Crude Distillation parallel units: A and B
	6. Crude Distillation Off-Gas Plant parallel units: A and B
	7. Platformer parallel units: 2 and 3
	8. Vacuum Distillation

[a] Refers to that portion of the FCC unit downstream of the main fractionator.

[b] Refers to that portion of the FCC unit that includes the feed lines, heaters, reactors, and the main fractionator.

(valve, pump, open-ended line, etc.), type of service (gas, light liquid, or heavy liquid), and the major organic components contained by the source and their approximate concentrations.

Radian Corporation evaluated the immediate effects of maintenance of leaking sources (those sources with screening values greater than or equal to 10,000 ppmv) at the Chevron refinery, where refinery personnel repaired (or removed from service) leaking sources within two working days of screening. Repaired sources included valves, open-ended lines, and sealed open-ended lines.

Pumps and compressors with screening values measured at the source of at least 1,000 ppmv were rescreened at various distances from the shaft. Correlations were developed to describe the relationship between screening value and distance from the shaft.

Refinery records, documenting previous screening inspections conducted to comply with the leak detection and repair program of Rule 466.1, were surveyed by an engineer. This review yielded information about previous source leak frequencies.

Refinery records were also surveyed for information pertaining to pump seal lifetime and maintenance history. The information was used to establish relationships between screening value and time since pump seal replacement.

Finally, information was recorded by GCA Corporation screening personnel at the Powerine refinery concerning process sampling procedures. Sampling frequency and fate of sample material were described by this information.

Quality assurance was an integral part of the program. Each hydrocarbon detector was subjected to the performance criteria test specified in EPA Method 21, included as Appendix B, before testing began. The instruments were calibrated before each day's survey, and the calibration was checked at the end of each day. Also, several specific leaking sources were screened each day by the screening teams to establish trends related to changes in the leak and to variability of the test methods. The field supervisor (the on-site engineer) also conducted quality assurance audits for each of the two-person screening teams to verify proper screening and instrument calibration procedures.

1.3 REPORT ORGANIZATION

A summary of the program to investigate the effectiveness of fugitive emission control regulations in the SCAQMD is presented in Section 2. The test methods used in the program are briefly described in Section 3. Detailed results of the program, including screening results, effects of maintenance, distance screening results, historical leak survey and repair records, pump seal failure/maintenance records, and information concerning refinery process sampling procedures are presented in Section 4.

SECTION 2

SUMMARY

2.0 CONSOLIDATED CONCLUSIONS/OBSERVATIONS

Seven areas of interest were investigated in a screening study coupled with an inspection of maintenance records and a historical review of the effects of previous inspections and maintenance performed under the South Coast Air Quality Management District (SCAQMD) rule 466.1 in two refineries.

The first area, screening of sources, provided data that indicates that among sources in the vapor pressure range of rule 466.1, the category of pumps has the highest rate of leaks at 17.2%, with all other categories at 5.5% or less.

The second area investigated, the immediate effects of maintenance, produced data to show that a weight percent reduction in emissions of 97% for open-ended lines and 96% reduction in valves could be attributed to the maintenance performed.

The third area, historical leak detection and repair data, provided data to indicate that leak frequency varied from unit to unit and from time to time, but that leak recurrence rates after three months ranged from zero to 19% with the average being 8% of the sources which had been repaired. The different population of sources tested at each inspection makes it difficult to draw conclusions on the effectiveness of rule 466.1.

The fourth area of concern, how screening at a distance from the emission source would change the readings and how readings taken at distances

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other than zero could be correlated, produced the equation for pump seals:

$$\text{screening value} = e^{7.72 - 0.364\,(d)}$$

where d = distance from the pump seal in cm.

A nomograph with confidence intervals is included.

The fifth area, pump seal replacement, provided data which showed a slight positive relationship between the screening value and time since last seal replacement, that is as a seal aged it tended to leak a bit more. Both operating and spare pumps were included in the data. The mean time between seal replacements was one to one and one-half years, and approximately 90% of the seals are replaced within 3 years.

The sixth area, process control sampling procedures used by the refinery, yielded information on the frequency, size, and disposition of liquid samples taken to monitor the refining process. The three to six one-gallon samples taken each day are routed either to sour water treatment or to the API separator after analysis. Both the quantity involved and the disposition indicate minimal contribution to fugitive emissions from process samples.

The seventh area, quality control, revealed that there was no bias between screening teams used in the project. There was very good agreement between test teams on whether or not a source was screening greater than or equal to 10,000 ppmv. Repeated screenings of the valves indicated that less than 20% of the observed variation in the screening values for a given valve was attributable to variations from the instrument or screening process. Data indicate that a mean screening value of X can be expected to be within $\frac{X}{2.5}$ and 2.5X 95% of the time.

More detailed discussion, by area and with report sections presenting the data for that area, follow.

2.1 SCREENING RESULTS (SECTION 4.1)

All sources in eight process units with greater than 10 percent VOC were scheduled for screening with a Century Systems OVA. Screening results are presented for sources except and subject to the vapor pressure criterion of SCAQMD Rule 466.1. Approximately 15 percent of the sources could not be screened, with location being the primary reason for not screening. Leaking sources (sources screening greater than or equal to 10,000 ppmv) were found at the following rates:

valves - 5.4%
pumps - 17.2%
open-ended lines - 4.8%
other sources - 5.5%

The number of leaking sources in each process unit is tabulated in Section 4.1. For valves in gas service, the leak frequency in the eight units ranged from zero to 5.7 percent. Control valves had a leak frequency (16.3 percent) greater than three times that of block valves (4.9 percent). On-line pumps had a leak frequency (22.6 percent) of greater than five times that of off-line pumps (4.1 percent).

2.2 IMMEDIATE EFFECTS OF MAINTENANCE (SECTION 4.2)

At the Chevron refinery, all valves and open-ended lines subject to the rule with screening values greater than or equal to 10,000 ppmv were repaired or taken out of service. Post-maintenance screening values were recorded for 342 repaired valves and open-ended lines. Leak rates were estimated from the screening values and a weight percent reduction in emissions estimated. The weight percent reduction was 97 percent for open-ended lines and 96 percent for valves.

2.3 HISTORICAL LEAK DETECTION AND REPAIR DATA (SECTION 4.3)

Refinery records from previous screening inspections were examined to evaluate the impact of inspections done to comply with Rule 466.1. Different populations of sources were tested during each inspection making it difficult to quantify the impact. The percent of sources screening greater than or equal to 10,000 ppmv at each inspection represents combined leak occurrence and recurrence rates. Because of the different populations and varying time periods between inspections, it is difficult to quantify these leak occurrence and recurrence rates. After the initial inspection, the leak frequency ranged from zero (Vacuum Distillation Unit) to a high of 11.7 percent (third inspection of FCC unit). Leak recurrence rates after three months ranged from zero to 19 percent, averaging about eight percent of the sources repaired.

2.4 DISTANCE SCREENING (SECTION 4.4)

Pump and compressor seals with a screening value at the source of greater than 1,000 ppmv were also screened at distances ranging from one to 20 cm from the leak source. A functional relationship between the screening value and the distance from the source was developed from the pump data. Significant differences between cources were observed for the rate of screening value decrease with distance. An overall model for the 32 pump seals studied was:

$$\text{Screening value} = e^{7.72-0.364\text{ (cm from source)}}$$

A nomograph for this model is included in Section 4.4 with confidence intervals. For example, using the nomograph, if the screening value obtained 2.5 cm from the source was 1,000 ppmv, then the predicted screening value at the source is 2,500 ppmv.

2.5 PUMP SEAL REPLACEMENT DATA (SECTION 4.5)

Refinery records were examined to evaluate pump seal replacement practices. For the pump seals in the vapor pressure range of rule 466.1, a slight positive relationship was seen between the screening value and the time since last seal replacement. The total available historical data indicated that 544 seals had been replaced in oi pumps. This includes both operating and spare pumps. The mean time between seal replacement was computed for each pump seal. The mean time averaged about 1.0 to 1.5 years. Cumulative distributions show that about 90% of the seals are replaced within three years.

2.6 PROCESS SAMPLING PROCEDURES (SECTION 4.6)

Information from the Powerine refinery indicates that one-gallon process samples are obtained from three to six times per day. The sample material is either routed to sour water treatment facilities or to an API separator. The sampled material could range from]8 to 47 lb/day depending on the density of the material sampled and the number of samples. No information was available on sample purging.

2.7 QUALITY CONTROL (APPENDIX D)

Quality control procedures were a part of all field testing during the program. Method 21 performance checks were performed on each screening instrument. Calibration checks were done daily on each instrument. Slight negative drifts in calibration were observed for one of the instruments. No consistent drifts in the dilution factor were observed. Repeated screenings each day were done on three of the valves at each refinery. Less than 20 percent of the total variation in the screening values for a given valve was attributable to variations from the instrument/screening process. Reported screening values for a source with a mean screening value of X can be expected to be within $\frac{X}{2.5}$ to 2.5X 95% of the time. Screening quality assurance audits indicated no biases between the different screening teams used in this project. Of the 38 sources determined to be screening greater than 10,000 ppmv by either the original or audit screens, 36 also had screening values greater than 10,000 ppmv at the other screening.

SECTION 3

TEST METHOD DESCRIPTION

General descriptions of the methods used in the program are presented in this section. More detailed discussions of these methods are included in Appendix C.

3.1 SCREENING PROCEDURES

Each process unit was precisely defined and process flow diagrams and plot plans were obtained for reference. Sources were then screened with a Century Systems OVA-108 portable hydrocarbon detector on a stream-by-stream basis. Only those sources containing at least 10 weight percent VOC were screened. Screening of a process unit was completed when all VOC sources were screened or identified as sources not screened (with reasons documented for not screening, e.g., inaccessible without extensive scaffolding or equipment aids).

Individual sources were screened by placing the hydrocarbon detector probe tip as close as possible to the area of suspected leakage. A slow traverse of the circumference of the area was made, and the maximum repeatable reading on the instrument was recorded as the screening value. If the initial traverse revealed that the screening value exceeded 10,000 ppmv (full-scale deflection on the OVA-108 readout meter), a 10:1 dilution probe was fitted to the detector probe to extend the concentration range of the instrument to 100,000 ppmv.

Pumps and compressor seals with screening values greater than 1,000 ppmv were screened at various distances from the shaft. A detachable and adjustable rod marked with the desired distances was fitted to the detector probe to provide repeatable distances for these screenings.

3.2 RECORDS SURVEY PROCEDURES

The following refinery information was examined:

- historical screening data collected after implementation of Rule 466.1 - to determine the effectiveness of the regulation;
- maintenance history of pump seals - to provide data on pump seal lifetimes; and
- procedures used for obtaining process samples - to determine the amount and fate of sample purge material.

Information was obtained from refinery records and from interviews with maintenance/sampling personnel.

3.3 DATA HANDLING

Data were recorded on alphanumeric coding sheets which were periodically sent to Radian Corporation for processing. Coding sheets were used for screening, distance screening, instrument calibration, repeat screening, and maintenance history.

3.4 QUALITY CONTROL PROCEDURES

Field data quality was maintained by observing the following procedures, the results of which are detailed in Appendix D:

- Method 21 instrument performance evaluation procedures - Instruments were subjected to the performance criteria specified by Method 21, which involve calibration precision and response time.
- Instrument calibration checks - The hydrocarbon detectors were calibrated before starting each day's survey, and the calibration was checked at the end of each day. The instruments were calibrated

with standard mixtures of 8,000 ppmv and 800 ppmv of methane in air.

- Repeat screening - Several leaking sources were screened each day by each screening team. Three screenings were performed within 30 minutes for each of these sources. The resulting screening values established trends related to changes in the leak and to variability of the test methods.

- Screening quality assurance audits - The field supervisor conducted quality assurance audits for each of the two-person screening teams. Approximately five percent of the sources screened by each team were also screened by the field supervisor. The field supervisor screened these sources within 30 minutes of the original screening. Instrument calibration was also verified during the quality assurance audit.

SECTION 4

TEST RESULTS

Detailed results of the program are generally presented in this section in one of three ways:

- overall basis - results represent a composite total of data for all process units in both refineries,
- process unit basis - results are presented for specific individual process units, and
- source basis - results pertain to specific individual source types (valve, pump, etc.).

Although most of the data are presented according to the above breakdowns, certain results are presented by refinery, e.g., quality control results and site-specific historical screening survey data compiled in compliance with Rule 466.1.

4.1 SCREENING RESULTS

Table 4-1 shows (for sources subject to and exempt from Rule 466.1 based on the vapor pressure criterion) the total number screened and not screened with the reasons that screening were not performed. The data are displayed by source type and stream service.[1] Table 4-2 summarizes the total number and percentage of leaking sources (sources with screening values

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[1] For this program, gas service refers to gas or vapor at process conditions. Liquids were classified based on their most volatile component present at 20 weight percent or more. If that component had a vapor pressure greater than kerosene, the material was classified as a light liquid; otherwise, it was classified as a heavy liquid.

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TABLE 4-1. SUMMARY OF SOURCES SCREENED AND NOT SCREENED -- ALL PROCESS UNITS

		Sources Subject to Rule										
						Number of Sources Not Screened due to Reason*						
Source Type	Stream Service	Number of Sources	Number Screened	Number Not Screened	Percent Not Screened	1	2	3	4	5	6	7
Open-Ended Lines	Gas	111	100	11	9.9	-	1	10	-	2	-	-
	Light Liquid	224	202	22	9.8	3	3	14	-	-	-	2
Sealed Open-Ended Lines	Gas	407	346	61	15.0	-	39	22	-	2	-	-
	Light Liquid	1173	1019	154	13.1	2	36	113	-	5	1	1
Open Process Drains	Light Liquid	87	87	0	0.0	-	-	-	-	-	-	-
Relief Valves	Gas	15	7	8	53.3	-	-	8	-	-	-	-
	Light Liquid	19	12	7	36.8	-	-	7	-	1	-	-
Valves	Gas	2553	2294	259	10.1	-	88	169	-	10	1	-
	Light Liquid	5447	4761	686	12.6	24	187	466	-	17	2	-
Pumps	Light Liquid	121	116	5	4.1	3	-	-	-	-	-	3
Compressors	Gas	13	10	3	23.1	1	2	-	-	-	-	-

*Reasons Source Not Screened:
1) Temporary factors such as sources taken out of service for repair.
2) Permanent factors such as sources that could not be reached without extraordinary aids.
3) Location, such as sources that could not be screened using the probe extension, but could be reached by using a stepladder.
4) High background concentration.
5) Accessible, but climbing not permitted.
6) Possible fouling of probe by visible leak to atmosphere.
7) Possible fouling of probe by visible leak to drain or sump.

(Continued)

TABLE 4-1. (Continued)

		Sources Exempt from Rule											
						Number of Sources Not Screened due to Reason*							
Source Type	Stream Service	Number of Sources	Number Screened	Number Not Screened	Percent Not Screened	1	2	3	4	5	6	7
Open-Ended Lines	Gas	13	13	0	0.0	-	-	-	-	-	-	-
	Light Liquid	35	25	10	28.6	-	-	4	2	-	1	3
	Heavy Liquid	46	37	9	19.6	-	-	9	-	-	-	-
	Unknown	1	1	0	0.0	-	-	-	-	-	-	-
Sealed Open-Ended Lines	Gas	8	2	6	75.0	-	-	5	1	-	-	-
	Light Liquid	23	22	1	4.4	1	-	-	-	-	-	-
	Heavy Liquid	37	25	12	32.4	-	-	11	1	9	-	-
Open Process Drains	Light Liquid	6	6	0	0.0	-	-	-	-	-	-	-
	Heavy Liquid	31	31	0	0.0	-	-	-	-	-	-	-
Relief Valves -	Light Liquid	4	0	4	100.0	-	1	3	-	-	-	-
	Heavy Liquid	3	2	1	66.7	-	-	1	-	-	-	-
Valves	Gas	77	52	25	32.5	-	-	24	1	-	-	-
	Light Liquid	230	175	55	23.9	-	-	55	-	-	-	-
	Heavy Liquid	399	285	114	28.6	-	-	104	4	34	1	-
Pumps	Light Liquid	22	17	5	22.7	2	-	-	-	-	1	2
	Heavy Liquid	50	40	10	20.0	2	2	-	-	-	-	8
Compressors	Gas	1	1	0	0.0	-	-	-	-	-	-	-

*Reasons Source Not Screened:

1) Temporary factors such as sources taken out of service for repair.
2) Permanent factors such as sources that could not be reached without extraordinary aids.
3) Location, such as sources that could not be screened using the probe extension, but could be reached by using a stepladder.
4) High background concentration.
5) Accessible, but climbing not permitted.
6) Possible fouling of probe by visible leak to atmosphere.
7) Possible fouling of probe by visible leak to drain or sump.

TABLE 4-2. SUMMARY OF SCREENING VALUES >10,000 PPMV -- ALL PROCESS UNITS

Source Type	Stream Service	Sources Subject to Rule Number Screened	Sources Subject to Rule Number ≥10,000	Sources Subject to Rule Percent ≥10,000	Sources Exempt from Rule Number Screened	Sources Exempt from Rule Number ≥10,000	Sources Exempt from Rule Percent ≥10,000
Open-Ended Lines	Gas	100	8	8.0	13	1	7.7
	Light Liquid	202	23	11.4	25	0	0.0
	Heavy Liquid	-	-	-	37	0	0.0
	Unknown	1	0	0.0	-	-	-
Sealed Open-Ended Lines	Gas	346	8	2.3	2	0	0.0
	Light Liquid	1019	41	4.0	22	0	0.0
	Heavy Liquid	-	-	-	25	0	0.0
Open Process Drains	Light Liquid	87	2	2.3	6	1	16.7
	Heavy Liquid	-	-	-	31	0	0.0
Relief Valves	Gas	7	1	14.3	-	-	-
	Light Liquid	12	0	0.0	-	-	-
	Heavy Liquid	-	-	-	2	0	0.0
Valves	Gas	2294	108	4.7	52	3	5.8
	Light Liquid	4761	274	5.8	175	3	1.7
	Heavy Liquid	-	-	-	284	0	0.0
Pumps	Light Liquid	116	20	17.2	17	0	0.0
	Heavy Liquid	-	-	-	40	0	0.0
Compressors	Gas	9	4	44.4	1	1	100.0
Others	Gas	1	0	0.0	-	-	-
	Light Liquid	11	0	0.0	-	-	-
TOTAL	Gas	2758	129	4.7	68	5	7.4
	Light Liquid	6208	360	5.8	245	4	1.6
	Heavy Liquid	-	-	-	419	0	0.0
	Unknown	1	0	0.0	-	-	-

greater than or equal to 10,000 ppmv) categorized by source type, stream service, and status with respect to Rule 466.1 (subject or exempt). Tables 4-3 through 4-10 present information similar to that presented in Table 4-2, except that the subsequent tables present the information on an individual process unit basis. Table 4-11 presents similar results for miscellaneous compressors, i.e., screened compressors that are not included within any of the eight process units.

Table 4-12 summarizes leak data for all valves by type: block or control. A breakdown of the Table 4-12 data by specific process unit is presented in Table 4-13.

Table 4-14 presents leak data for on-line and off-line pumps by specific process unit. Of the 173 pump seals screened, 155 were single mechanical with the emission point at the seal, 15 seals were single packed with the emission point at the seal, two seals were single packed with the emission point at other than the seal or vent, and one seal was single mechanical with the emission point at the vent.

Ten of the thirteen compressor seals were screened. Information pertaining to leak frequency and status with respect to Rule 466.1 is as follows:

- One seal was in on-line duty. It leaked and was subject to the rule.
- Nine seals were off-line.
  - One of these seals was exempt from the rule and leaked.
  - Three seals were subject to the rule and leaked.
  - Five seals were subject to the rule and did not leak.

Of these 10 compressor seals, four were single packed with the emission point at the seal, and two leaked. Three seals were single packed with the emission point at the vent, and none leaked. Three seals were single packed with the emission point at other than the seal or vent, and they leaked.

TABLE 4-3. SUMMARY OF SCREENING VALUES ≥10,000 PPMV -- ALKYLATION

		Sources Subject to Rule			Sources Exempt from Rule		
Source Type	Stream Service	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Open-Ended Lines	Gas	6	1	16.7	-	-	-
	Light Liquid	76	9	11.8	-	-	-
Sealed Open-Ended Lines	Gas	26	0	0.0	-	-	-
	Light Liquid	412	26	6.3	-	-	-
	Unknown	1	0	0.0	-	-	-
Open Process Drains	Light Liquid	10	1	10.0	-	-	-
Relief Valves	Gas	3	0	0.0	-	-	-
	Light Liquid	1	0	0.0	-	-	-
Valves	Gas	148	20	13.5	-	-	-
	Light Liquid	2062	165	8.0	-	-	-
Pumps	Light Liquid	53	11	20.8	-	-	-
Others	Light Liquid	2	0	0.0	-	-	-
TOTAL	Gas	183	21	11.5	-	-	-
	Light Liquid	2616	212	8.1	-	-	-
	Unknown	1	0	0.0	-	-	-

TABLE 4-4. SUMMARY OF SCREENING VALUES >10,000 PPMV-- ISOMAX (HYDROCRACKING)

		Sources Subject to Rule			Sources Exempt from Rule		
Source Type	Stream Service	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Open-Ended Lines	Gas	3	0	0.0	-	-	-
	Light Liquid	24	0	0.0	-	-	-
	Unknown	1	0	0.0	-	-	-
Sealed Open-Ended Lines	Gas	78	3	3.9	-	-	-
	Light Liquid	288	2	0.69	-	-	-
Open Process Drains	Light Liquid	21	0	0.0	-	-	-
	Heavy Liquid	-	-	-	18	0	0.0
Relief Valves	Gas	1	0	0.0	-	-	-
	Light Liquid	4	0	0.0	-	-	-
Valves	Gas	803	25	3.1	-	-	-
	Light Liquid	1180	22	1.9	-	-	-
Pumps	Light Liquid	24	5	20.8	-	-	-
	Heavy Liquid	-	-	-	11	0	0.0
Others	Light Liquid	1	0	0.0	-	-	-
TOTAL	Gas	885	28	3.2	-	-	-
	Light Liquid	1542	29	1.9	-	-	-
	Heavy Liquid	-	-	-	29	0	0.0
	Unknown	1	0	0.0	-	-	-

TABLE 4-5. SUMMARY OF SCREENING VALUES ≥10,000 PPMV -- FCC GAS RECOVERY

		Sources Subject to Rule			Sources Exempt from Rule		
Source Type	Stream Service	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Open-Ended Lines	Gas	39	4	10.3	-	-	-
	Light Liquid	37	2	5.4	-	-	-
Sealed Open-Ended Lines	Gas	153	3	2.0	-	-	-
	Light Liquid	178	11	6.2	-	-	-
Open Process Drains	Light Liquid	38	0	0.0	-	-	-
Valves	Gas	725	41	5.7	-	-	-
	Light Liquid	883	67	7.6	-	-	-
Pumps	Light Liquid	22	2	9.1	7	0	0.0
	Heavy Liquid	-	-	-	8	0	0.0
Compressors	Gas	2	2	100.0	-	-	-
Others	Gas	1	0	0.0	-	-	-
	Light Liquid	1	0	0.0	-	-	-
TOTAL	Gas	921	50	5.4	-	-	-
	Light Liquid	1166	82	7.0	7	0	0.0
	Heavy Liquid	-	-	-	8	0	0.0

TABLE 4-6. SUMMARY OF SCREENING VALUES $\geq$10,000 PPMV -- FCC GAS REACTOR

		Sources Subject to Rule			Sources Exempt from Rule		
Source Type	Stream Service	Number Screened	Number $\geq$10,000	Percent $\geq$10,000	Number Screened	Number $\geq$10,000	Percent $\geq$10,000
Open-Ended Lines	Gas	3	1	33.3	-	-	-
Sealed Open-Ended Lines	Gas	29	1	3.5	-	-	-
Valves	Gas	139	6	4.3	-	-	-
Pumps	Light Liquid	4	0	0.0	-	-	-
	Heavy Liquid	-	-	-	12	0	0.0
TOTAL	Gas	171	8	4.7	-	-	-
	Light Liquid	4	0	0.0	-	-	-
	Heavy Liquid	-	-	-	12	0	0.0

TABLE 4-7. SUMMARY OF SCREENING VALUES ≥10,000 PPMV -- CRUDE DISTILLATION

		Sources Subject to Rule			Sources Exempt from Rule		
Source Type	Stream Service	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Open-Ended Lines	Gas	14	1	7.1	-	-	-
	Light Liquid	41	5	12.2	17	0	0.0
	Heavy Liquid	-	-	-	9	0	0.0
Sealed Open-Ended Lines	Gas	19	1	5.3	-	-	-
	Light Liquid	121	0	0.0	13	0	0.0
	Heavy Liquid	-	-	-	13	0	0.0
Open Process Drains	Light Liquid	12	0	0.0	3	0	0.0
	Heavy Liquid	-	-	-	2	0	0.0
Relief Valves	Light Liquid	5	0	0.0	-	-	-
Valves	Gas	165	2	1.2	-	-	-
	Light Liquid	470	9	1.9	114	1	0.88
	Heavy Liquid	-	-	-	102	0	0.0
Pumps	Light Liquid	6	0	0.0	8	0	0.0
	Heavy Liquid	-	-	-	5	0	0.0
TOTAL	Gas	198	4	2.0	-	-	-
	Light Liquid	660	15	2.3	155	1	0.65
	Heavy Liquid	-	-	-	131	0	0.0

TABLE 4-8. SUMMARY OF SCREENING VALUES ≥10,000 PPMV -- CRUDE DISTILLATION - OFF GAS PLANT

		Sources Subject to Rule			Sources Exempt from Rule		
Source Type	Stream Service	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Open-Ended Lines	Gas	18	0	0.0	-	-	-
	Light Liquid	1	1	100.0	5	0	0.0
Sealed Open-Ended Lines	Gas	11	0	0.0	-	-	-
	Light Liquid	2	0	0.0	2	0	0.0
Relief Valves	Gas	2	1	50.0	-	-	-
Valves	Gas	125	7	5.6	-	-	-
	Light Liquid	10	0	0.0	-	-	-
	Heavy Liquid	-	-	-	2	0	0.0
Compressors	Gas	2	2	100.0	-	-	-
TOTAL	Gas	158	10	6.3	-	-	-
	Light Liquid	13	1	7.7	-	-	-
	Heavy Liquid	-	-	-	2	0	0.0

TABLE 4-9. SUMMARY OF SCREENING VALUES ≥10,000 PPMV -- PLATFORMER

Source Type	Stream Service	Sources Subject to Rule			Sources Exempt from Rule		
		Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Open-Ended Lines	Gas	15	1	6.7	13	1	7.7
	Light Liquid	23	6	26.1	3	0	0.0
Sealed Open-Ended Lines	Gas	19	0	0.0	2	0	0.0
	Light Liquid	18	2	11.1	7	0	0.0
Open Process Drains	Light Liquid	6	1	16.7	1	0	0.0
Relief Valves	Light Liquid	2	0	0.0	-	-	-
Valves	Gas	151	7	4.6	52	3	5.8
	Light Liquid	156	11	7.1	37	2	5.4
Pumps	Light Liquid	2	1	50.0	1	0	0.0
	Heavy Liquid	-	-	-	1	0	0.0
Compressors	Gas	1	0	0.0	1	1	100.0
TOTAL	Gas	185	8	4.3	68	5	7.4
	Light Liquid	207	21	10.1	49	2	4.1
	Heavy Liquid	-	-	-	1	0	0.0

TABLE 4-10. SUMMARY OF SCREENING VALUES ≥10,000 PPMV -- VACUUM DISTILLATION

		Sources Subject to Rule			Sources Exempt from Rule		
Source Type	Stream Service	Number Screened	Number ≥10,000	Percent >10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Open-Ended Lines	Gas	2	0	0.0	-	-	-
	Light Liquid	-	-	-	5	0	0.0
	Heavy Liquid	-	-	-	28	0	0.0
Sealed Open-Ended Lines	Gas	11	0	0.0	-	-	-
	Light Liquid	-	-	-	2	0	0.0
	Heavy Liquid	-	-	-	12	0	0.0
Open Process Drains	Light Liquid	-	-	-	2	1	50.0
	Heavy Liquid	-	-	-	11	0	0.0
Relief Valves	Gas	1	0	0.0	-	-	-
	Heavy Liquid	-	-	-	2	0	0.0
Valves	Gas	38	0	0.0	-	-	-
	Light Liquid	-	-	-	24	0	0.0
	Heavy Liquid	-	-	-	180	0	0.0
Pumps	Light Liquid	-	-	-	1	0	0.0
	Heavy Liquid	-	-	-	3	0	0.0
Compressors	Gas	1	0	0.0	-	-	-
TOTAL	Gas	53	0	0.0	-	-	-
	Light Liquid	-	-	-	34	1	2.9
	Heavy Liquid	-	-	-	236	0	0.0

TABLE 4-11. SUMMARY OF SCREENING VALUES >10,000 PPMV -- MISCELLANEOUS COMPRESSORS

		Sources Subject to Rule			Sources Exempt from Rule		
Source Type	Stream Service	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Compressors	Gas	4	0	0.0	-	-	-
TOTAL	Gas	4	0	0.0	-	-	-

TABLE 4-12. SUMMARY OF SCREENING VALUES ⩾10,000 PPMV -- BLOCK VALVES VS. CONTROL VALVES, ALL PROCESS UNITS

		Valves Subject to Rule			Valves Exempt from Rule		
Stream Service	Valve Type	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Gas	Block	2204	88	4.0	52[1]	3	5.8
	Control	90	20	22.2	-	-	-
Light Liquid	Block	4550	245	5.4	166	3	1.8
	Control	211	29	13.7	9	0	0.0
Heavy Liquid	Block	-	-	-	270	0	0.0
	Control	-	-	-	14	0	0.0
TOTAL	Block	6754	333	4.9	488	6	1.2
	Control	301	49	16.3	23	0	0.0

[1] Valves in hydrogen service.

TABLE 4-13. SUMMARY OF SCREENING VALUES ≥10,000 PPMV -- BLOCK VALVES VS. CONTROL VALVES

			Valves Subject to Rule			Valves Exempt from Rule		
Process Unit	Stream Service	Valve Type	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Alkylation	Gas	Block	137	17	12.4	-	-	-
		Control	11	3	27.3	-	-	-
	Light Liquid	Block	1994	148	7.4	-	-	-
		Control	68	17	25.0	-	-	-
Isomax (Hydro-cracking)	Gas	Block	780	20	2.6	-	-	-
		Control	23	5	21.7	-	-	-
	Light Liquid	Block	1110	20	1.8	-	-	-
		Control	70	2	2.9	-	-	-
FCC Gas Recovery	Gas	Block	702	35	5.0	-	-	-
		Control	23	6	26.1	-	-	-
	Light Liquid	Block	840	58	6.9	-	-	-
		Control	58	9	20.9	-	-	-
FCC Gas Reactor	Gas	Block	131	4	3.1	-	-	-
		Control	8	2	25.0	-	-	-

(CONTINUED)

TABLE 4-13. (CONT.)

Process Unit	Stream Service	Valve Type	Valves Subject to Rule Number Screened	Valves Subject to Rule Number ≥10,000	Valves Subject to Rule Percent ≥10,000	Valves Exempt from Rule Number Screened	Valves Exempt from Rule Number ≥10,000	Valves Exempt from Rule Percent ≥10,000
Crude Distillation	Gas	Block	160	2	1.3	-	-	-
		Control	5	0	0.0	-	-	-
	Light Liquid	Block	450	8	1.8	107	1	0.93
		Control	20	1	5.0	7	0	0.0
	Heavy Liquid	Block	-	-	-	98	0	0.0
		Control	-	-	-	4	0	0.0
Off-Gas Plant	Gas	Block	119	6	5.0	-		-
		Control	6	1	16.7	-	-	-
	Light Liquid	Block	9	0	0.0	-	-	-
		Control	1	0	0.0	-	-	-
	Heavy Liquid	Block	2	0	0.0	-	-	-
Platformer	Gas	Block	138	4	2.9	52	3	5.8
		Control	13	3	23.1	-	-	-
	Light Liquid	Block	147	11	7.5	36	2	5.6
		Control	9	0	0.0	1	0	0.0
Vacuum Distilltion	Gas	Block	37	0	0.0	-	-	-
		Control	1	0	0.0	-	-	-
	Light Liquid	Block	-	-	-	23	0	0.0
		Control	-	-	-	1	0	0.0
	Heavy Liquid	Block	-	-	-	170	0	0.0
		Control	-	-	-	10	0	0.0

TABLE 4-14. SCREENING VALUES OF ON-LINE AND OFF-LINE PUMPS BY PROCESS UNIT AND STREAM SERVICE

		Light Liquid-Subject to Rule			Light Liquid-Exempt from Rule			Heavy Liquid		
Process Unit	Pump	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Alkylation	Off-Line	24	2	8.3	-	-	-	-	-	-
	On-Line	29	9	31.0	-	-	-	-	-	-
Isomax (Hydro-cracking)	Off-Line	14	3	21.4	-	-	-	5	0	0.0
	On-Line	10	2	20.0	-	-	-	6	0	0.0
FCC Gas Recovery	Off-Line	9	0	0.0	5	0	0.0	5	0	0.0
	On-Line	13	2	15.4	2	0	0.0	3	0	0.0
FCC Gas Reactor	Off-Line	3	0	0.0	-	-	-	9	0	0.0
	On-Line	1	0	0.0	-	-	-	3	0	0.0
Crude Distillation	Off-Line	3	0	0.0	3	0	0.0	1	0	0.0
	On-Line	8	1	12.5	5	0	0.0	4	0	0.0
Platformer	Off-Line	1	1	100.0	-	-	-	1	0	0.0
	On-Line	1	0	0.0	1	0	0.0	-	-	-
Vacuum Distillation	Off-Line	-	-	-	1	0	0.0	-	-	-
	On-Line	-	-	-	1	0	0.0	3	0	0.0
TOTAL	Off-Line	54	6	4.1	8	0	0.0	21	0	0.0
	On-Line	62	14	22.6	9	0	0.0	19	0	0.0

TABLE 4-14. SCREENING VALUES OF ON-LINE AND OFF-LINE PUMPS BY PROCESS UNIT AND STREAM SERVICE

		Light Liquid-Subject to Rule			Light Liquid-Exempt from Rule			Heavy Liquid		
Process Unit	Pump	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000	Number Screened	Number ≥10,000	Percent ≥10,000
Alkylation	Off-Line	24	2	8.3	-	-	-	-	-	-
	On-Line	29	9	31.0	-	-	-	-	-	-
Isomax (Hydrocracking)	Off-Line	14	3	21.4	-	-	-	5	0	0.0
	On-Line	10	2	20.0	-	-	-	6	0	0.0
FCC Gas Recovery	Off-Line	9	0	0.0	5	0	0.0	5	0	0.0
	On-Line	13	2	15.4	2	0	0.0	3	0	0.0
FCC Gas Reactor	Off-Line	3	0	0.0	-	-	-	9	0	0.0
	On-Line	1	0	0.0	-	-	-	3	0	0.0
Crude Distillation	Off-Line	3	0	0.0	3	0	0.0	1	0	0.0
	On-Line	8	1	12.5	5	0	0.0	4	0	0.0
Platformer	Off-Line	1	1	100.0	-	-	-	1	0	0.0
	On-Line	1	0	0.0	1	0	0.0	-	-	-
Vacuum Distillation	Off-Line	-	-	-	1	0	0.0	-	-	-
	On-Line	-	-	-	1	0	0.0	3	0	0.0
TOTAL	Off-Line	54	6	4.1	8	0	0.0	21	0	0.0
	On-Line	62	14	22.6	9	0	0.0	19	0	0.0

Figures 4-1 through 4-15 represent inverse cumulative distribution functions of screening values for source type/stream service groups which had at least eight sources with screening values greater than zero. The cumulative function for the sample data is plotted as well as the function derived from a mixed-lognormal model fit to the screening values. Approximate 95 percent confidence intervals are shown for the estimated function based on the mixed-lognormal model.

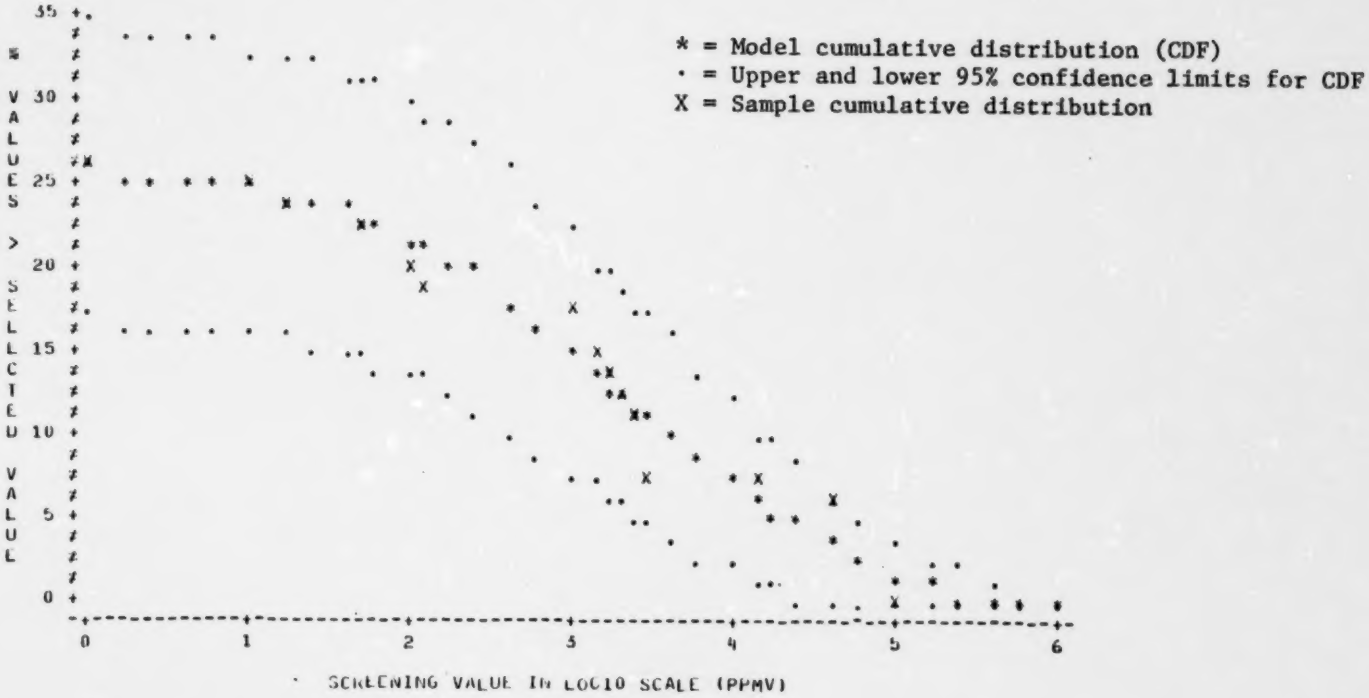

Figure 4-1. Inverse cumulative distribution function of screening values Open-ended lines--gas service

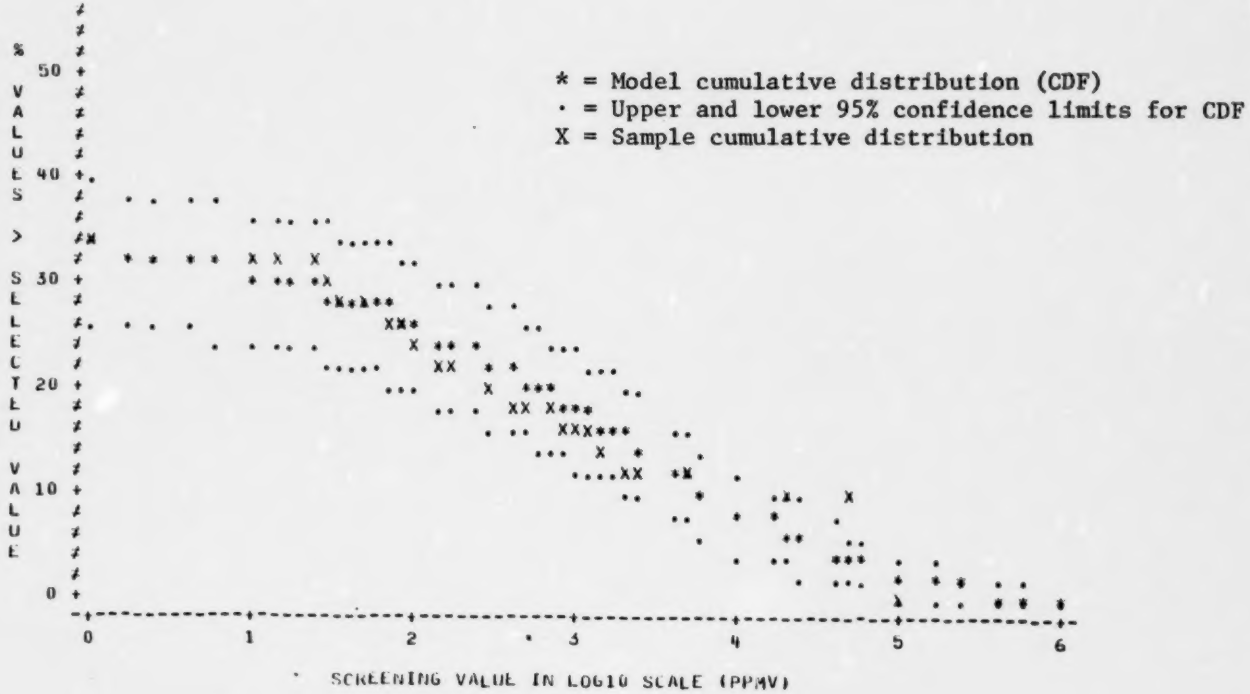

Figure 4-2. Inverse cumulative distribution function of screening values Open-ended lines--light liquid service

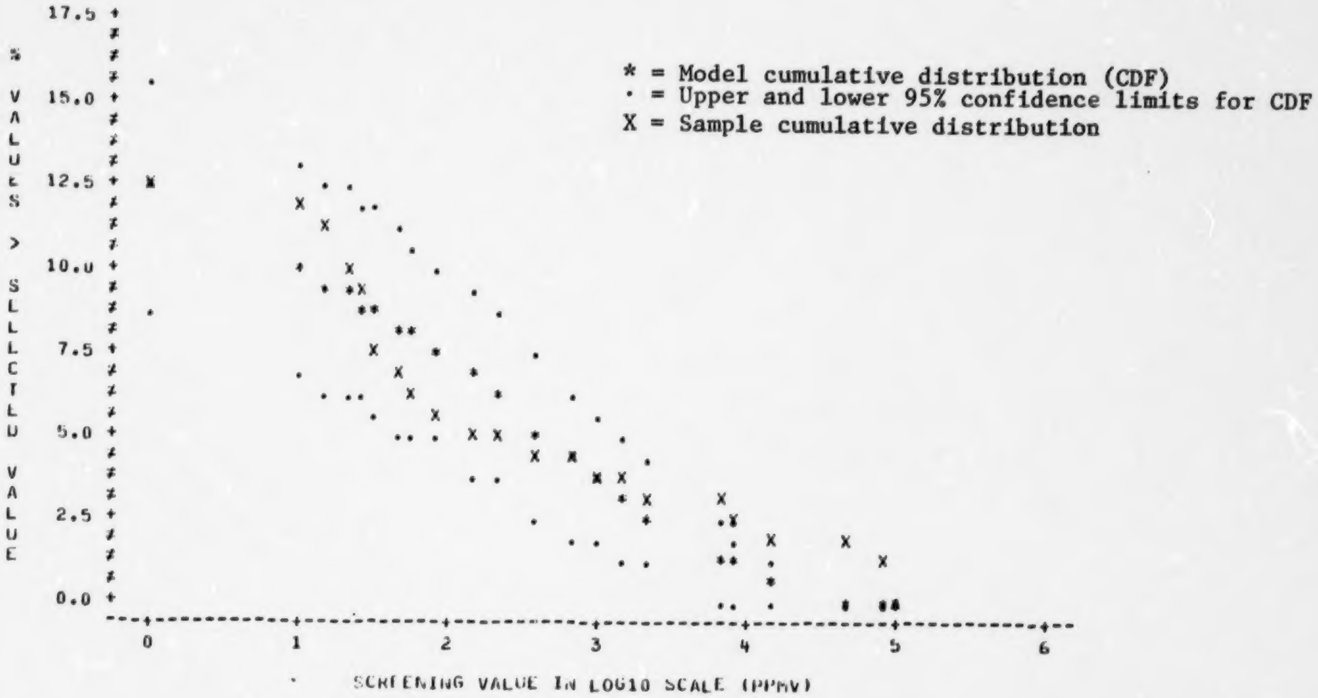

Figure 4-3. Inverse cumulative distribution function of screening values Sealed open-ended lines--gas service

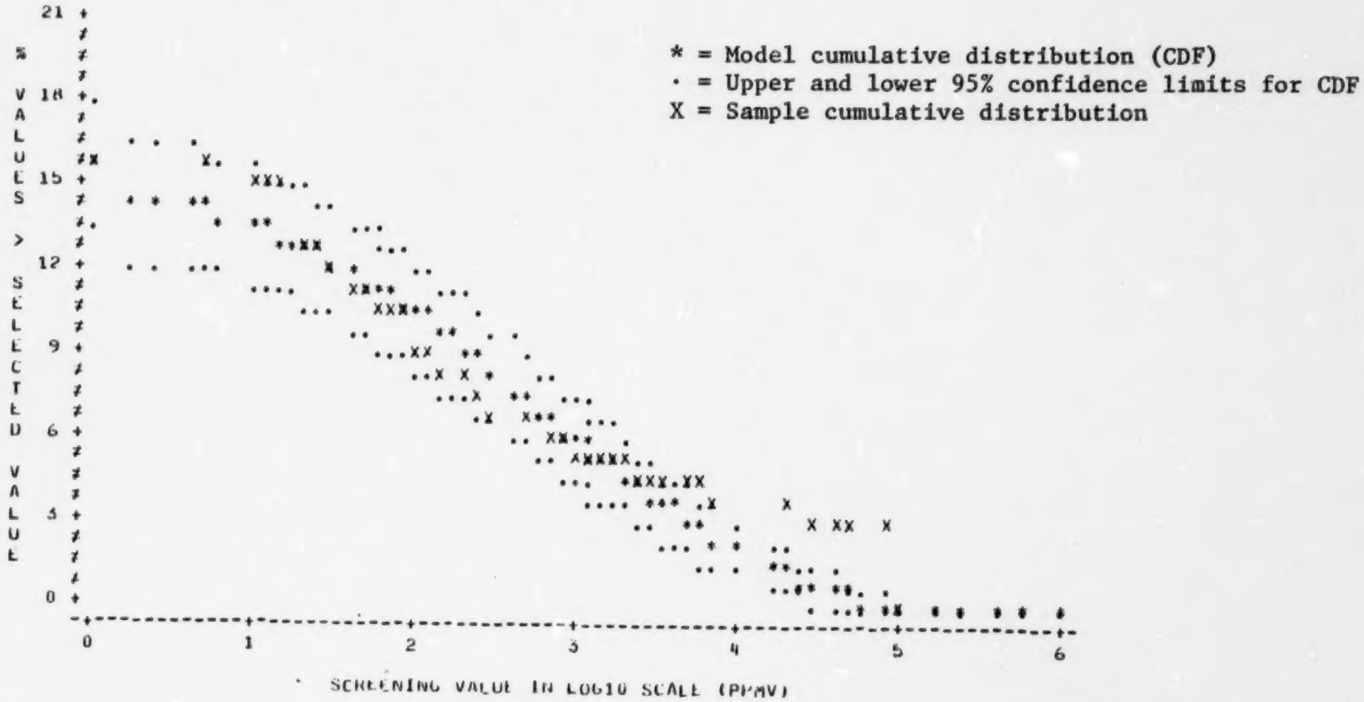

Figure 4-4. Inverse cumulative distribution function of screening values
Sealed open-ended lines--light liquid service

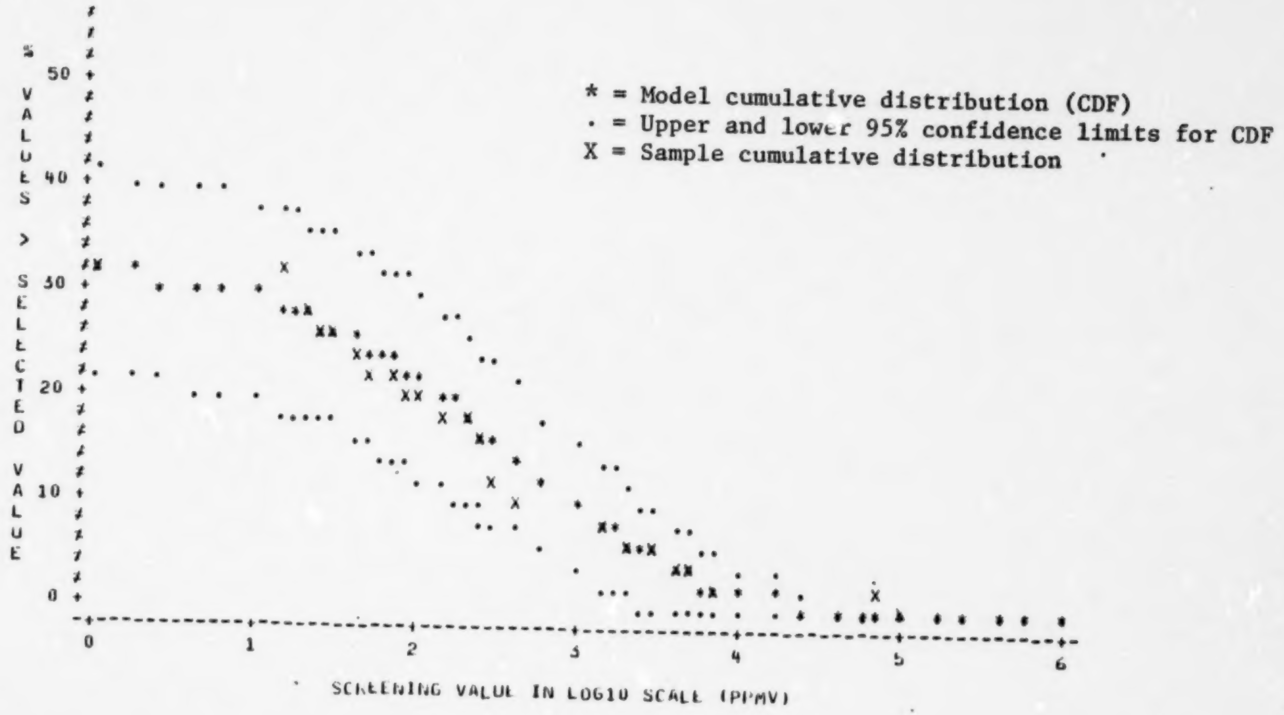

Figure 4-5. Inverse cumulative distribution function of screening values Open process drain--light liquid service

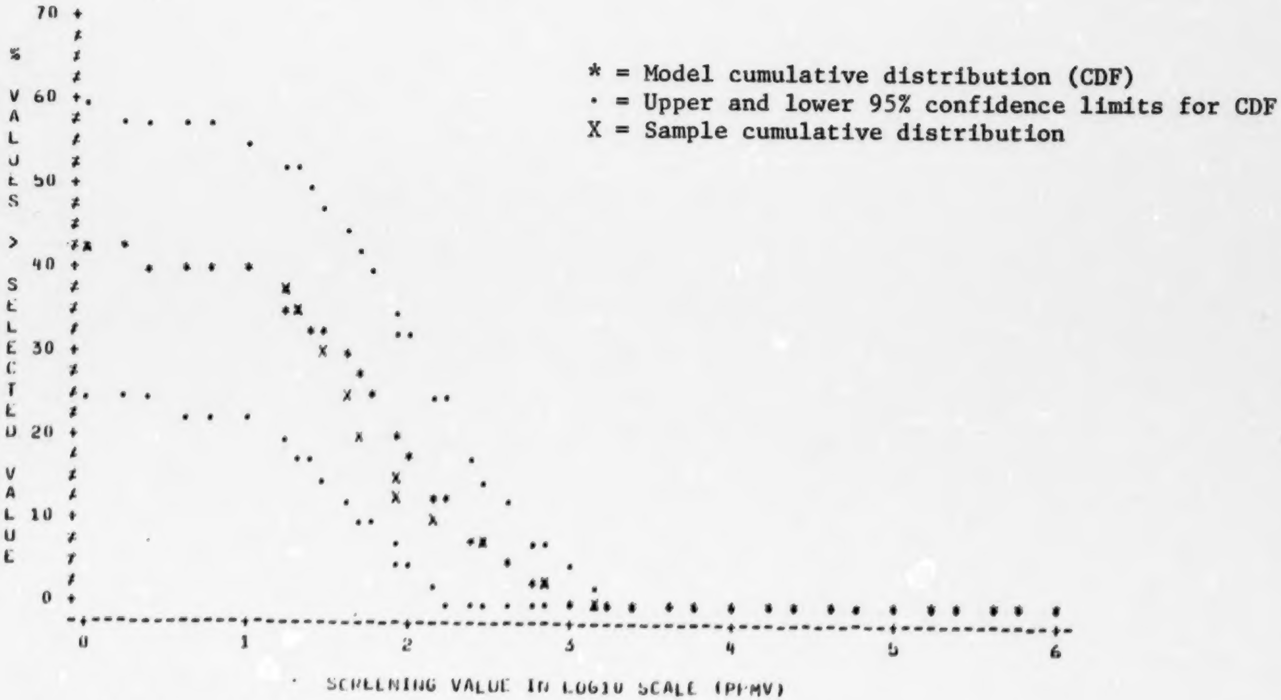

Figure 4-6. Inverse cumulative distribution function of screening values Open process drain--heavy liquid service

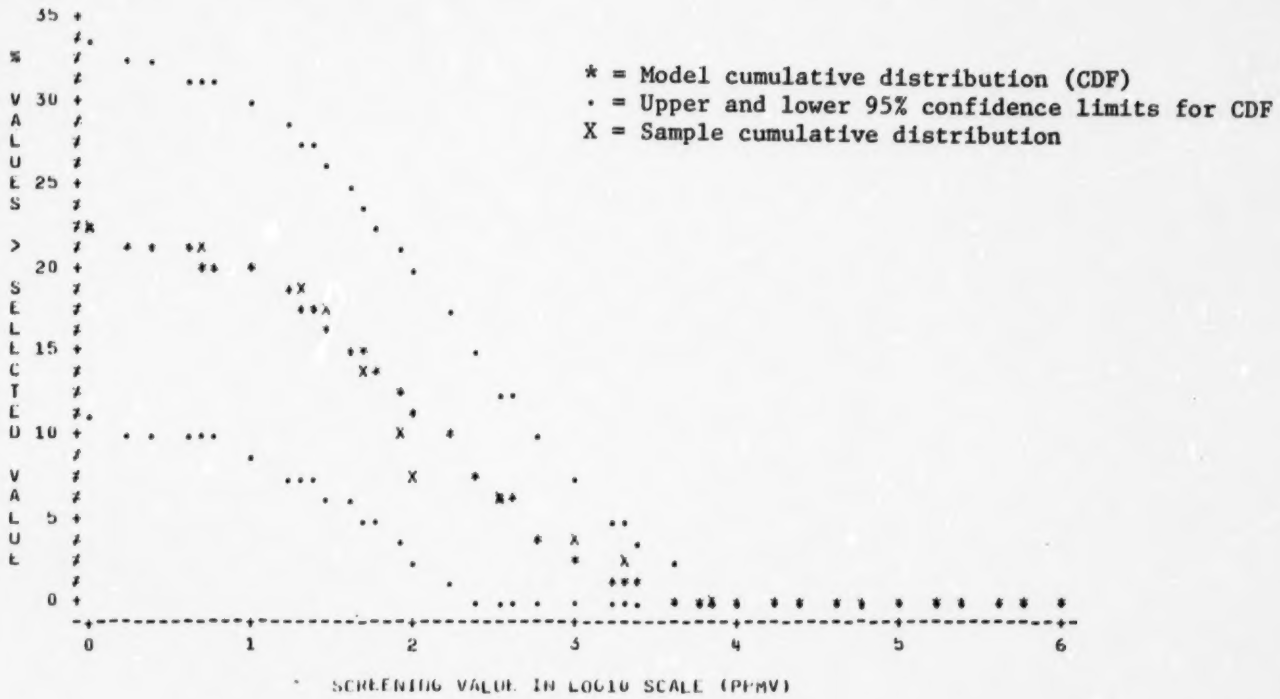

Figure 4-7. Inverse cumulative distribution function of screening values Open wash-up drain

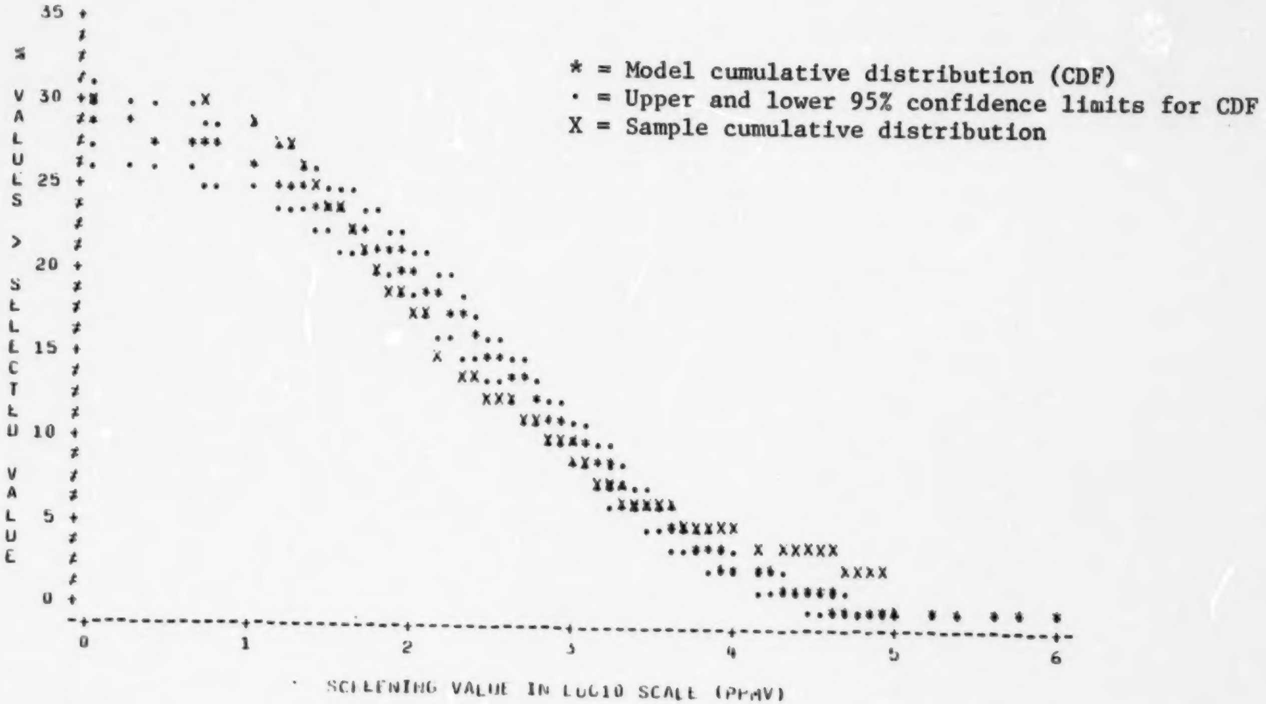

Figure 4-8. Inverse cumulative distribution function of screening values Valves--gas service

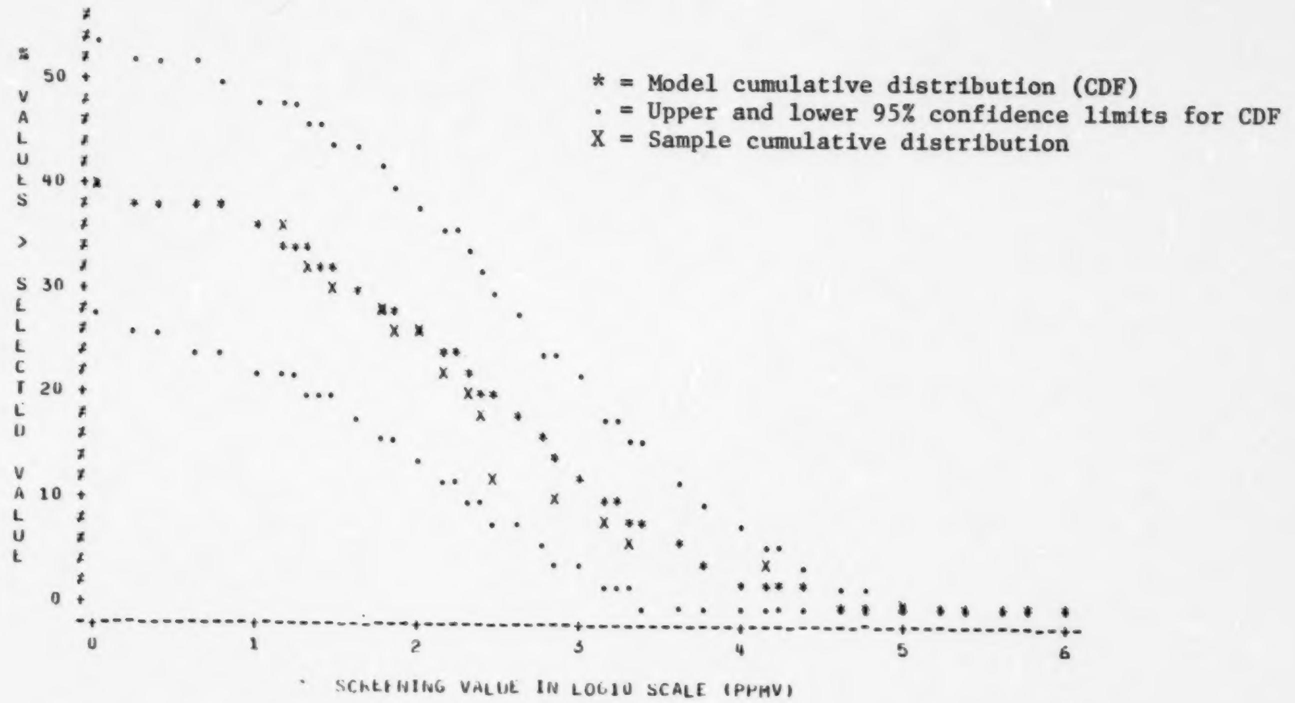

Figure 4-9. Inverse cumulative distribution function of screening values Valves--gas service, exempt from rule

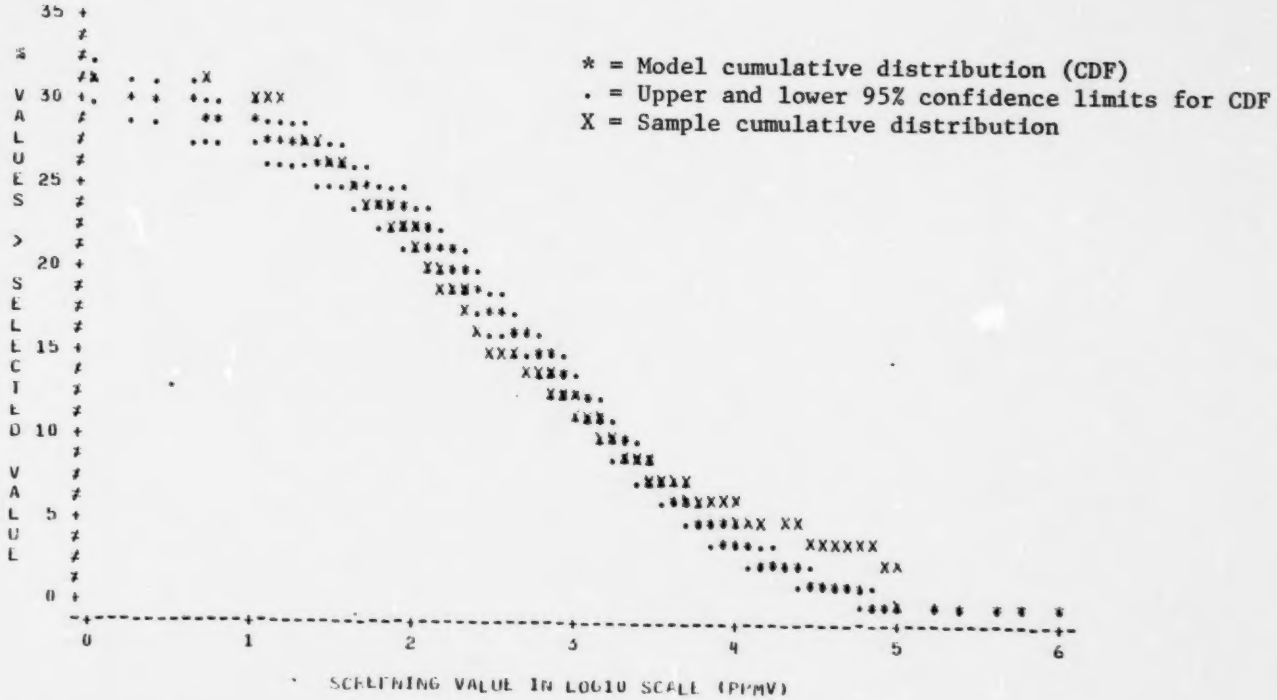

Figure 4-10. Inverse cumulative distribution function of screening values Valves--light liquid service

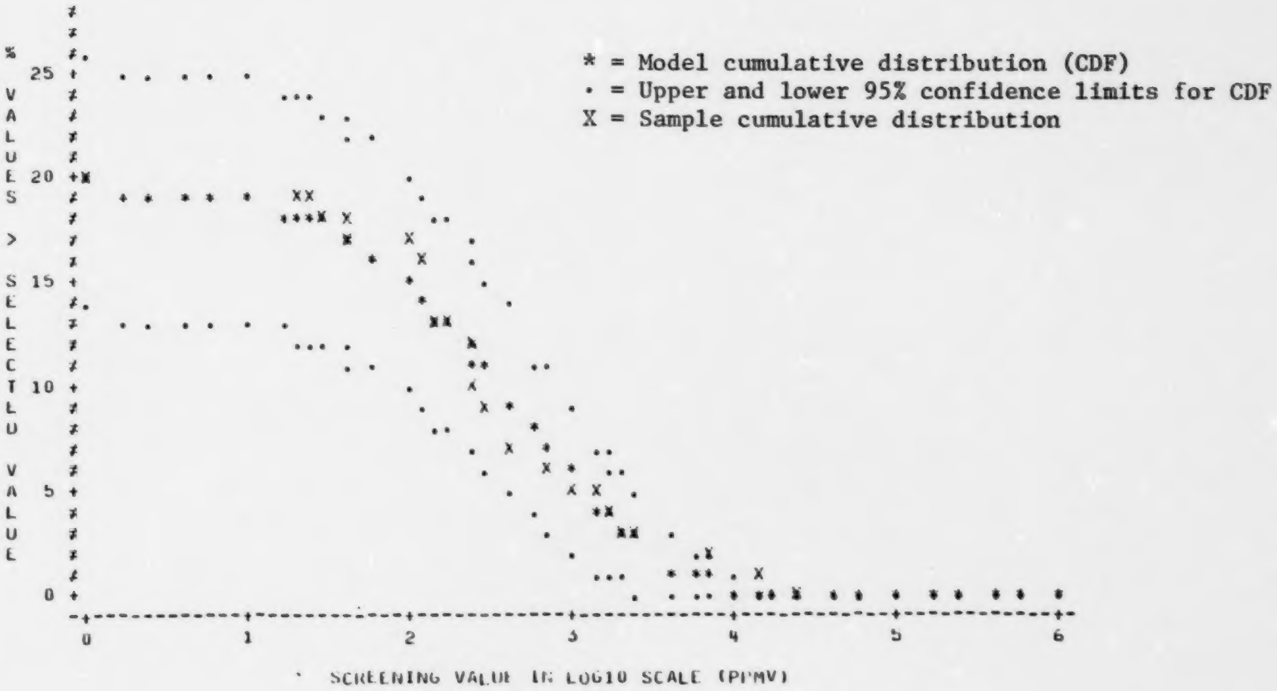

Figure 4-11. Inverse cumulative distribution function of screening values Valves--light liquid service, exempt from rule

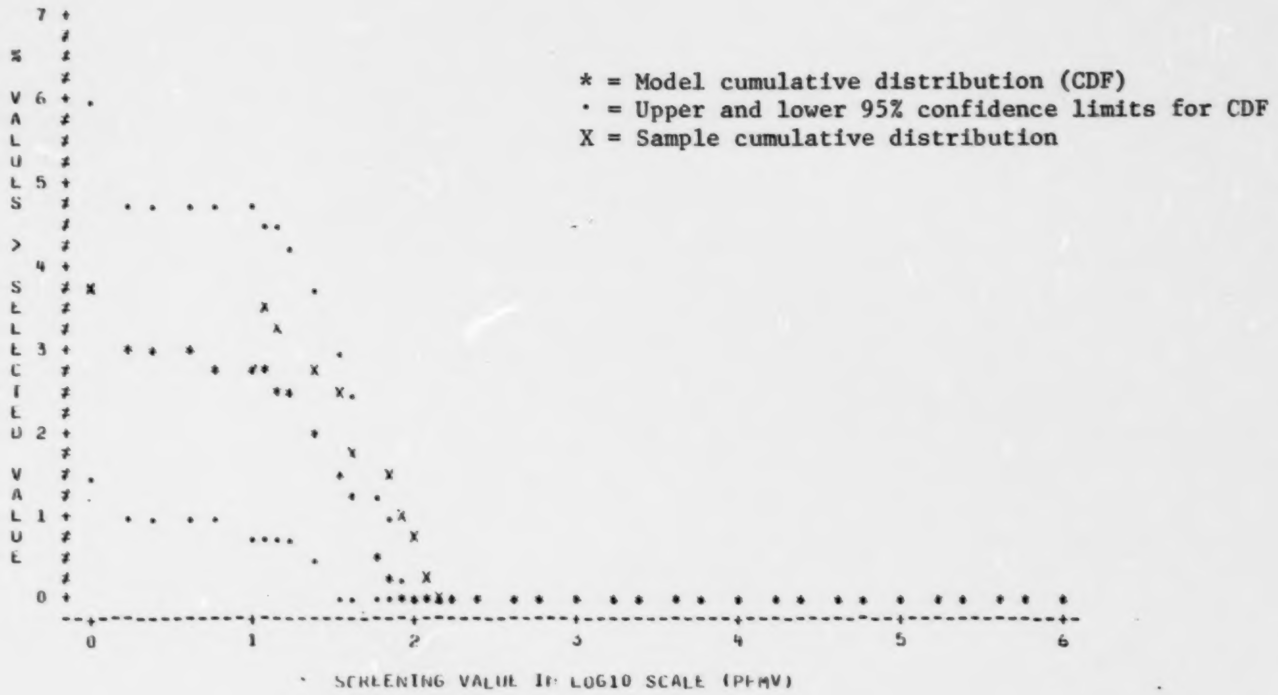

Figure 4-12. Inverse cumulative distribution function of screening values
Valves--heavy liquid service

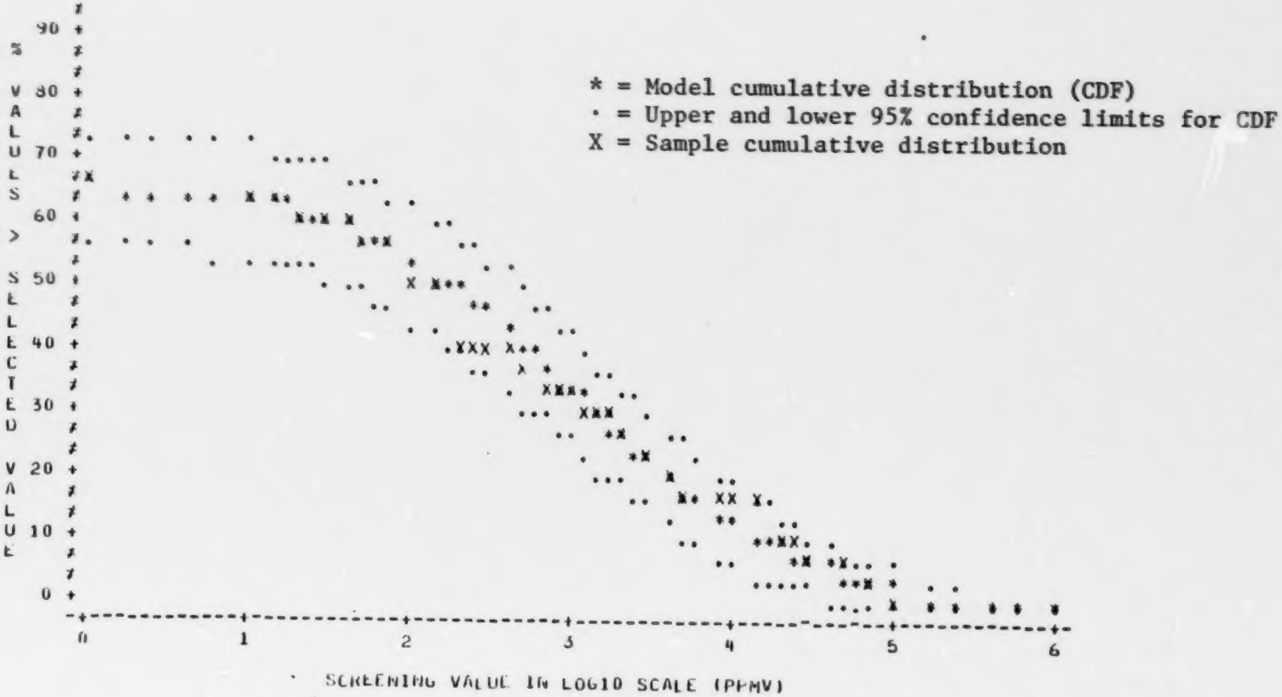

Figure 4-13. Inverse cumulative distribution function of screening values Pumps--light liquid service

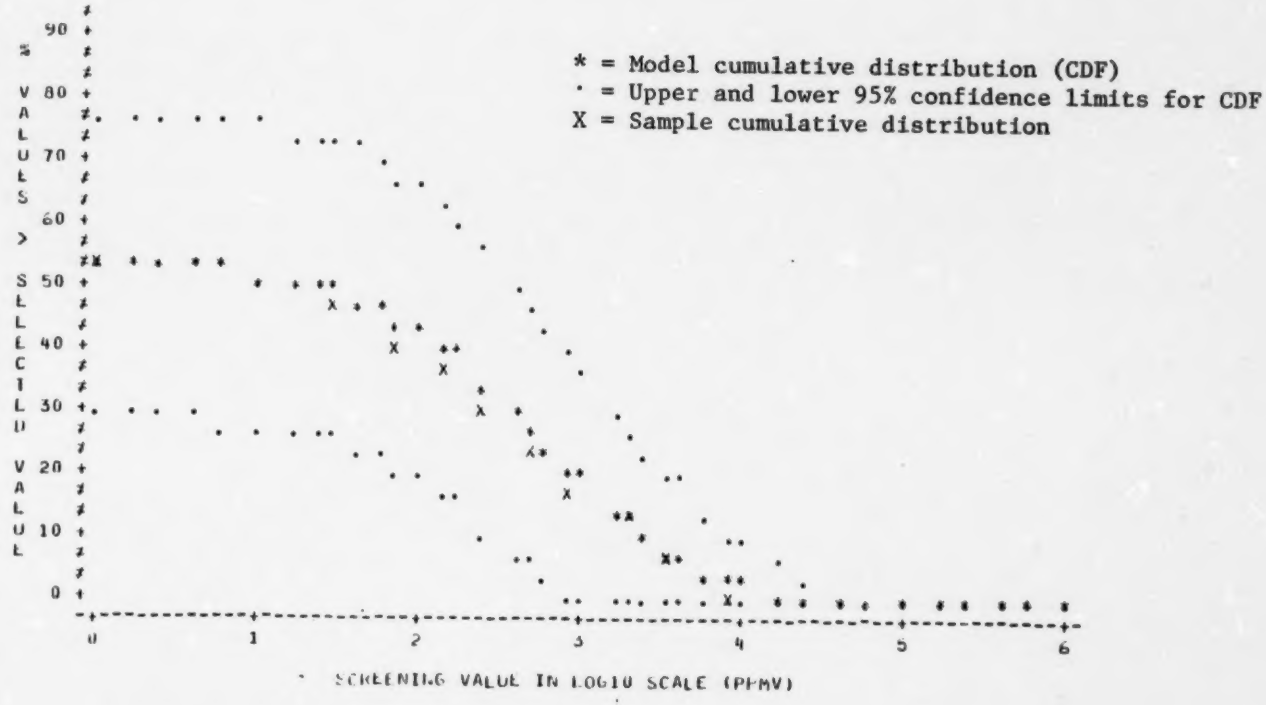

Figure 4-14. Inverse cumulative distribution function of screening values Pumps--light liquid service, exempt from rule

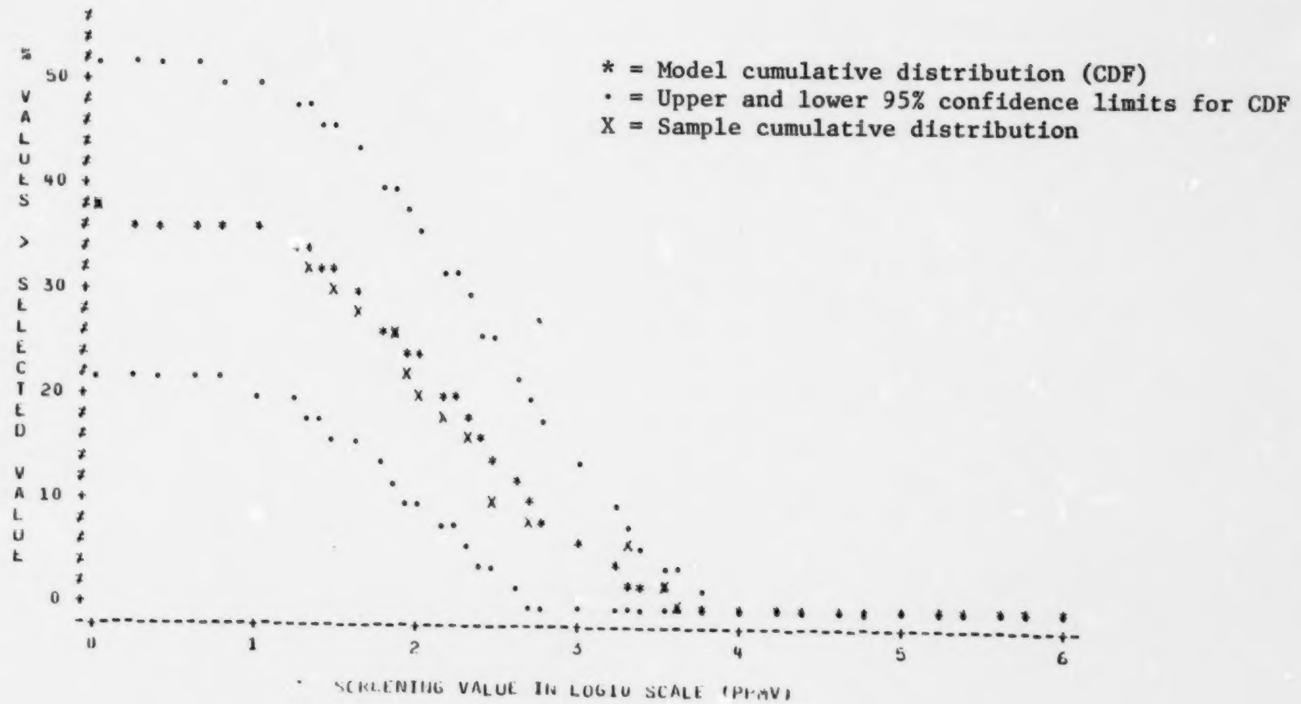

Figure 4-15. Inverse cumulative distribution function of screening values
Pumps--heavy liquid service

4.2 IMMEDIATE EFFECTS OF MAINTENANCE

During the screening program conducted at the Chevron refinery, all valves and open-ended lines which were subject to Rule 466.1 and which had a screening value $\geq$ 10,000 ppmv were repaired or taken out of service within two working days. Of 347 valves with screening values $\geq$ 10,000 ppmv, 344 post-maintenance values were recorded and three valves were taken out of service. Post-maintenance screening values were recorded for 41 open-ended lines. Powerine Oil Company did not use GCA Corporation's inspection as an inspection required by Rule 466.1, so sources were not necessarily maintained. Maintenance efforts at Chevron ranged from simple packing adjustment to sealant injection and valve replacement. The type of maintenance performed for each source was not recorded.

To estimate the percentage reduction in emission rates from maintenance of valves and open-ended lines, the relationships between screening value and leak rate developed in a previous report[1] were used. Since the leak rate/screening value relationships in this previous study were developed using a TLV-sniffer, the OVA reading was first converted using:

$$\log_{10}(\text{TLV}) = -0.193 + .952 \log_{10}(\text{OVA}).$$

Leak rates were then estimated for the converted screening values using:

$$\text{Gas Service: leak rate (lbs/hr)} = 10^{[-7.0 + 1.23 \log_{10}(\text{TLV}) + 0.78(\varepsilon)]}$$

$$\text{Liquid Service = leak rate (lbs/hr)} = 10^{[-4.9 + 0.8 \log_{10}(\text{TLV}) + 0.60(\varepsilon)]}$$

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[1] Wetherold, R.G. and D.D. Rosebrook. Environmental Assessment of Atmospheric Emissions from Petroleum Refining - Volume III. (NTIS No. PB80-225-253) U.S. Environmental Protection Agency, Research Triangle Park, NC, 1980.

where ε is a standard normal random value generated for each source. These equations are given in the previously referenced report. Figures 4-16 and 4-17 are plots of the estimated before vs. post-maintenance leak rate for open-ended lines and valves.

The Weight Percent Reduction (WPR) was used to estimate the percentage that the total estimated mass emissions were reduced due to maintenance. The WPR was calculated as follows:

$$\text{WPR} = \frac{(\sum^{m} \text{estimated mass emissions before maintenance} - \sum^{m} \text{estimated mass emissions after maintenance}) \times 100\%}{\sum^{m} \text{estimated mass emissions before maintenance}}$$

Since random values were used in the estimation of the leak rates, the estimated process was repeated 50 times, and the WPR computed for each simulation. From these 50 estimates, the average WPR and approximate 95 percent confidence intervals for the WPR were calculated. Table 4-15 shows the estimated WPR and 95 percent confidence limits for the maintained open-ended lines and various groupings of the maintained valves.

TABLE 4-15. EFFECTS OF VALVE MAINTENANCE ON EMISSIONS

Source Type	Stream Service	Number of Sources	Weight Percent Reduction (WPR)	Approximate 95% Confidence Intervals for WPR
open-ended lines	gas	6	98.8	(98, 99+)
	liquid	35	97.1	(93, 99)
All open-ended lines		41	97.4	(94, 99)
Block Valves	gas	77	98.9	(97, 99)
	liquid	226	94.7	(89, 97)
Control Valves	gas	16	93.8	(69, 99)
	liquid	28	96.1	(91, 99)
All valves		347	95.7	(90, 98)

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[1] Wetherold, R.G. and D.D. Rosebrook. Environmental Assessment of Atmospheric Emissions from Petroleum Refining - Volume III. (NTIS No. PB 80-225-253) U.S. Environmental Protection Agency, Research Triangle Park, NC, 1980.

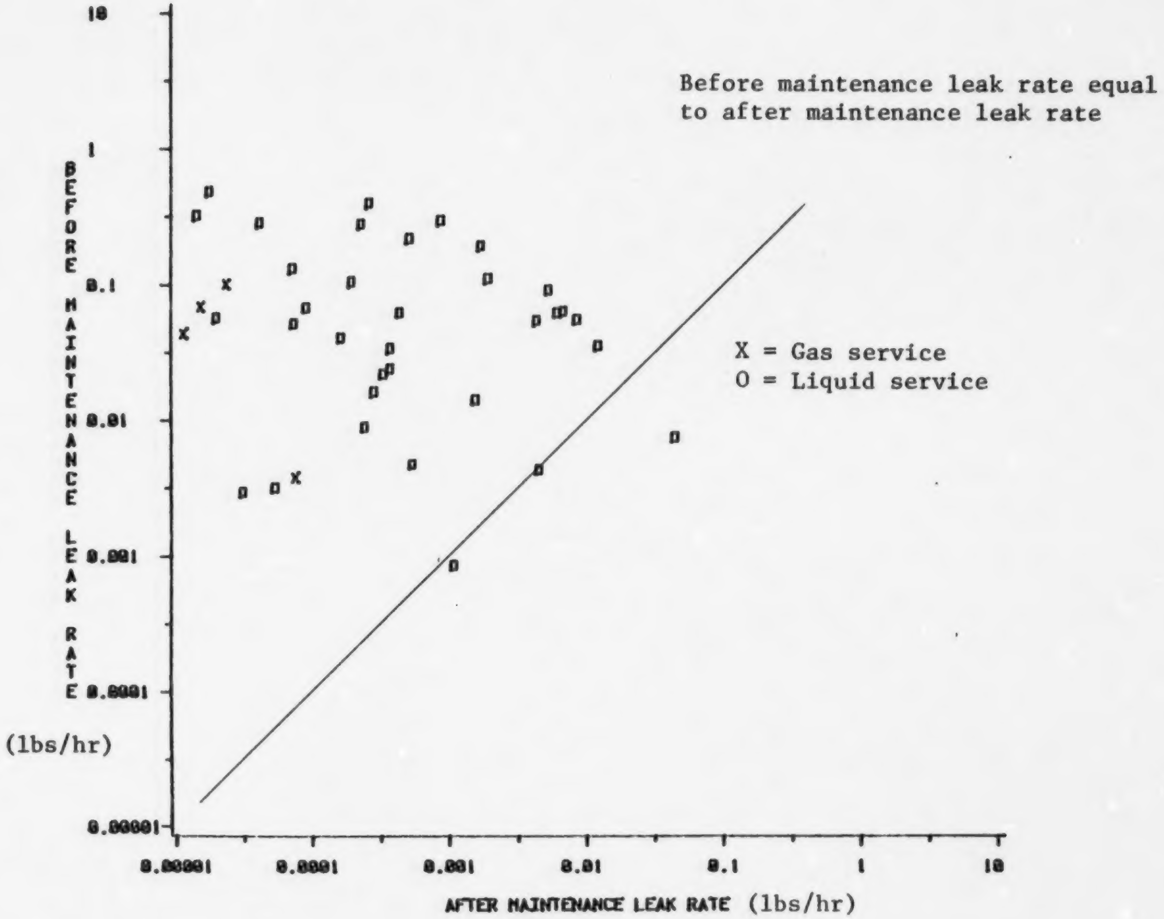

Figure 4-16. Before Maintenance vs. Post-Maintenance Estimated Leak Rate - Open-Ended Lines

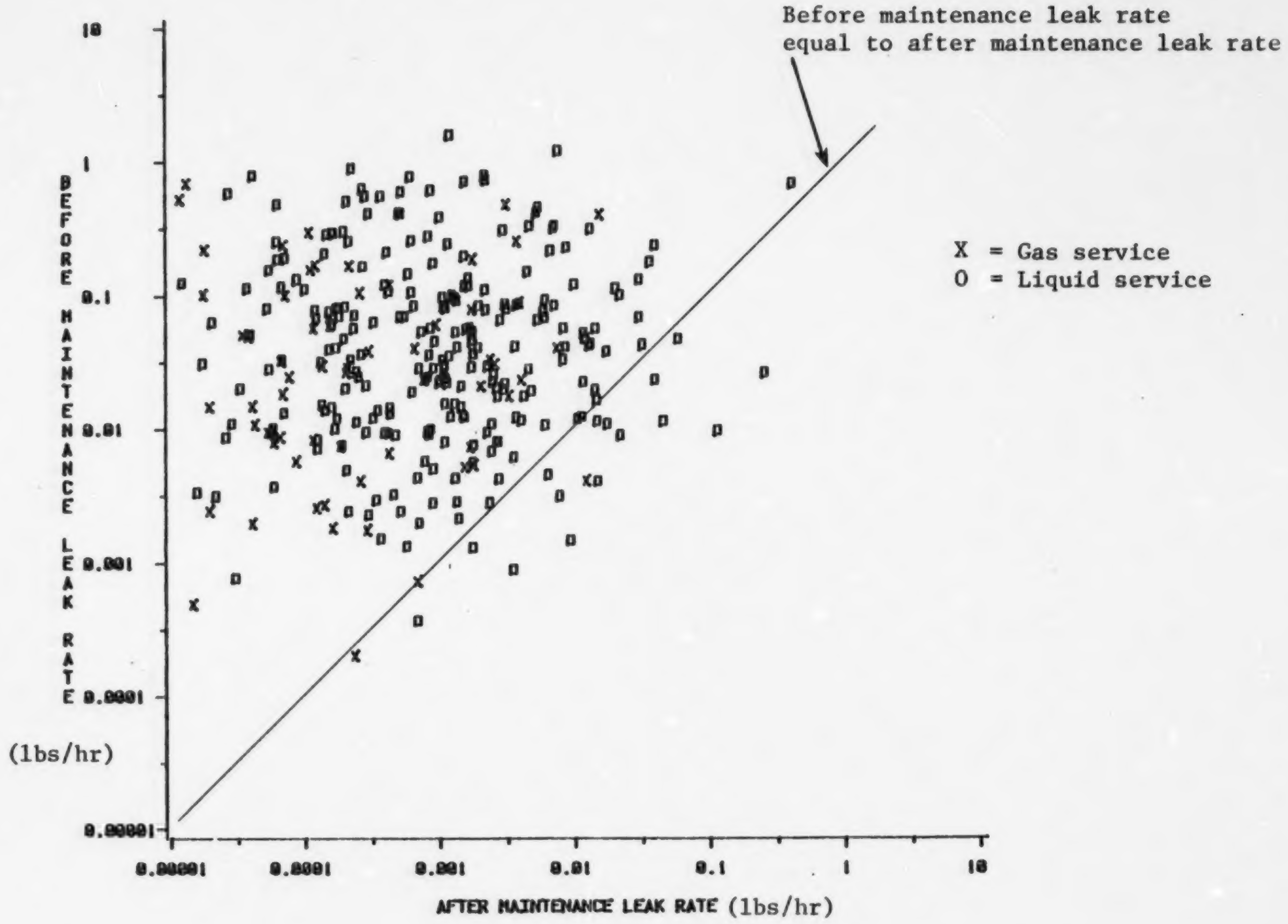

Figure 4-17. Before Maintenance vs. Post-Maintenance Estimated Leak Rate - Valves

4.3 HISTORICAL DATA FOR LEAK DETECTION AND REPAIR PROGRAM

Records from previous screening inspections at each refinery were examined. Most of the previous screening data were obtained by specific subunits or parallel units, as categorized in Table 1-1, rather than by the eight process units defined for this program. Because of these variances, Radian Corporation and GCA Corporation screening data were also subdivided by subunit and parallel unit and grouped appropriately so that valid comparisons could be made to previous refinery screening data. The changes in the population of sources screened in each unit at each screening period limit the ability to make comparisons.

Radian Corporation obtained the results of three previous screening inspections performed at the Chevron refinery to comply with Rule 466.1. Two inspections were completed in 1979, and one was completed in 1980. The screening effort by Radian represented the fourth inspection for the refinery. Records were obtained for the aklylation separator subunit, the Isomax hydrocracking process unit, and the FCC gas recovery and reactor process units. Results of the four screening inspections for valves are summarized in Table 4-16.

GCA Corporation obtained the results of two previous screening inspections performed in 1979 and 1980 at the Powerine refinery's crude distillation (parallel units A and B) and platformer (parallel unit No. 3) process units. Also, results were obtained for a 1980 inspection of the platformer (parallel unit No. 2) and vacuum distillation process units. The screening effort by GCA represented the third inspection at the refinery.

Results of the inspections of valves at the Powerine refinery are also summarized in Table 4-16. Fewer sources were screened during the first inspection than during the second inspection, perhaps because of unfamiliarity with Rule 466.1. The Powerine refinery records did not contain information about the number of sources not screened due to inaccessibility and other reasons.

TABLE 4-16. HISTORICAL LEAK FREQUENCY DATA FOR VALVES FROM RECORDS OF PREVIOUS INSPECTIONS UNDER RULE 466.1

Process Unit	Month of Screening	Percent Not Screened	Number Screened	Number[1] ≥10,000	Percent ≥10,000	Number and percent of repaired valves found ≥10,000 at inspection							
						3 Months		1 Month		2 Weeks		1 Week	
						Number	Percent	Number	Percent	Number	Percent	Number	Percent
Alkylation[2]	2/79[3]	10.3	1768	257	14.5	34	13.2	1	2.9	0	0.0	-	-
	7/79[3]	1.1	2043	111	5.4	16	14.4	8	50.0	3	37.5	1	33.3
	9/80[4]	5.2	1931	159	8.2	9	5.7	0	0.0	-	-	-	-
	2/81[3,5]	2.3	1700	153	9.0	0	0.0	-	-	-	-	-	-
Isomax	7/79[3]	5.0	1818	48	2.6	0	0.0	-	-	-	-	-	-
	9/79[3]	4.3	1860	41	2.2	2	4.9	2	100.0	0	0.0	-	-
	10/80[4]	9.0	2322	84	3.6	6	7.1	0	0.0	-	-	-	-
	2/81[3,5]	4.8	1983	47	2.4	0	0.0	-	-	-	-	-	-
FCC[6]	3/79[3]	4.5	1925	79	4.1	15	19.0	2	13.3	1	50.0	0	0.0
	8/79[3]	5.8	1949	24	1.2	4	16.0	4	100.0	0	0.0	-	-
	9/80[4]	6.4	1983	232	11.7	20	8.6	4	20.0	0	0.0	-	-
	2/81[3,5]	9.0	1749	115	6.6	0	0.0	-	-	-	-	-	-
Crude Distillation & Off-Gas Plant[7]	11/79[4]	-	264[8]	4	1.5	0	-	-	-	-	-	-	-
	9/80[4]	-	722	24	3.3	1	-	-	-	-	-	-	-
	3/81[3,5]	29.4	770	18	2.3	-	-	-	-	-	-	-	-
Platformer	11/79[4]	-	233	19	8.2	2	-	-	-	-	-	-	-
	9/80[4]	-	171	6	3.5	-	-	-	-	-	-	-	-
	3/81[3,5]	20.3	307	18	5.9	-	-	-	-	-	-	-	-
Vacuum Distillation	10/80[4]	-	37	0	0.0	0	-	-	-	-	-	-	-
	3/81[3,5]	36.0	38	0	0.0	-	-	-	-	-	-	-	-

NOTE: The total number of sources available for screening changed with time.

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[1] The number of valves with screening values ≥10,000 ppmv reflect the combined effect of occurrence and recurrence; these numbers may be impacted by the changing source populations.

[2] Records were obtained for the alkylation separator subunit only.

[3] Screening performed with Century OVA 108 calibrated with methane.

[4] Screening performed with Century OVA 108 calibrated with hexane.

[5] Contractor's inspection.

[6] Refinery records do not distinguish between FCC Gas Recovery and FCC Gas Reactor.

[7] Refinery records do not distinguish between crude distillation and off-gas plant.

[8] Does not include any fuel gas valves or crude lines; many rule sources missed.

4.4 DISTANCE SCREENING

Forty pump and four compressor seals, which had a screening value at the source greater than or equal to 1,000 ppmv, were screened at 1 cm, 2.5 cm, 5 cm, 10 cm, and 20 cm from the leak source. If the maximum concentration observed at one of these distances was less than 100 ppmv, additional screenings at greater distances were not performed. On one day of screening at the Powerine refinery, March 21, 1981, there was a high (approximately 100 ppmv) background concentration, so that 100 ppmv was subtracted from screening values which were less than 1,000 ppmv for each distance. Table 4-17 is a listing of the distance screening data for pumps and compressors. Since data from only four compressors were available, only the pump seal data were further analyzed.

Figures 4-18 and 4-19 are plots of screening values at each of the distances for a selected pump and a compressor. Plots for the remaining pumps and compressors are not included, but show a similar trend. These plots suggest a functional relationship between screening value and distance. The model tested for a functional relationship for pump seals is:

$$Y_{ij} = e^{B_o + B_i X_j}$$

where:

Y_{ij} = screening value for pump i at distance j;
X_j = distance j (cm) from leak source;
B_o = the natural logarithm of the screening value at the source;
B_i = rate of decrease in screening value as X increases.

Three questions concerning the model were investigated:

TABLE 4-17
LISTING OF PUMPS AND COMPRESSORS WITH DISTANCE SCREENING VALUES

LISTING OF PUMPS WITH UISTANCE SCREENING VALUES

OBS	ID	PUMPS	0 CM	1 CM	2.5 CM	5 CM	10 CM	20 CM
1	1123	OFFLINE	13000	2000	200	50	.	.
2	1126	ONLINE	2000	250	110	60	.	.
3	1129	OFFLINE	30000	20000	7000	2000	600	70
4	1130	OFFLINE	30000	500	300	50	.	.
5	1136	OFFLINE	100001	100001	10000	2000	300	30
6	1137	OFFLINE	20000	5000	1000	500	.	.
7	1138	OFFLINE	7000	2000	700	50	.	.
8	1141	OFFLINE	2000	1000	600	80	.	.
9	1145	ONLINE	40000	15000	1000	100	.	.
10	1146	ONLINE	100001	20000	2000	500	100	40
11	1148	ONLINE	5000	200	40	.	.	.
12	1150	OFFLINE	20000	4000	700	300	30	.
13	1151	ONLINE	20000	5000	300	70	.	.
14	1158	ONLINE	100001	100001	100001	40000	30000	10001
15	1163	OFFLINE	5000	700	300	50	.	.
16	3895	ONLINE	8000	500	110	50	.	.
17	5276	ONLINE	20000	7000	800	500	.	.
18	5278	OFFLINE	3500	200	200	35	.	.
19	6153	ONLINE	1500	900	250	70	.	.
20	6154	ONLINE	3000	700	100	25	.	.
21	5301	OFFLINE	100001	100001	35000	7000	1200	300
22	5302	OFFLINE	30000	20000	350	80	.	.
23	5303	OFFLINE	3000	700	50	.	.	.
24	5307	ONLINE	3500	150	50	.	.	.
25	5309	OFFLINE	30000	10000	4000	600	200	20
26	5310	ONLINE	1500	350	130	90	.	.
27	6168	ONLINE	30000	20000	2000	700	30	.
28	6174	ONLINE	20000	2000	500	70	.	.
29	17751	OFFLINE	2000	500	40	.	.	.
30	18363	ONLINE	30000	10000	1500	400	100	30
31	100003	OFFLINE	25000	30	.	.	.	.
32	4202	ONLINE	9000	6000	2000	800	800	100
33	4120	ONLINE	100001	100001	100001	30000	500	200
34	2579	ONLINE	1800	1000	950	200	150	.
35	2805	ONLINE	50000	700	350	.	.	.
36	3650	ONLINE	2000	800	250	.	.	.
37	3651	ONLINE	1100	800	500	350	50	.
38	3441	ONLINE	1500	1500	600	.	.	.
39	1299	ONLINE	1800	1500	900	400	125	.
40	130[illegible]	OFFLINE	4500	1600	250	200	125	.

LISTING OF COMPRESSORS WITH DISTANCE SCREENING VALUES

OBS	ID	COMPRESSOR	0 CM	1 CM	2.5 CM	5 CM	10 CM	20 CM
1	6057	ONLINE	100001	100001	60000	10000	5000	1000
2	4203	ONLINE	100001	100001	100001	100001	100001	10000
3	5056	ONLINE	100001	100001	100001	100001	5500	1500
4	7004	ONLINE	9000	4000	500	.	.	.

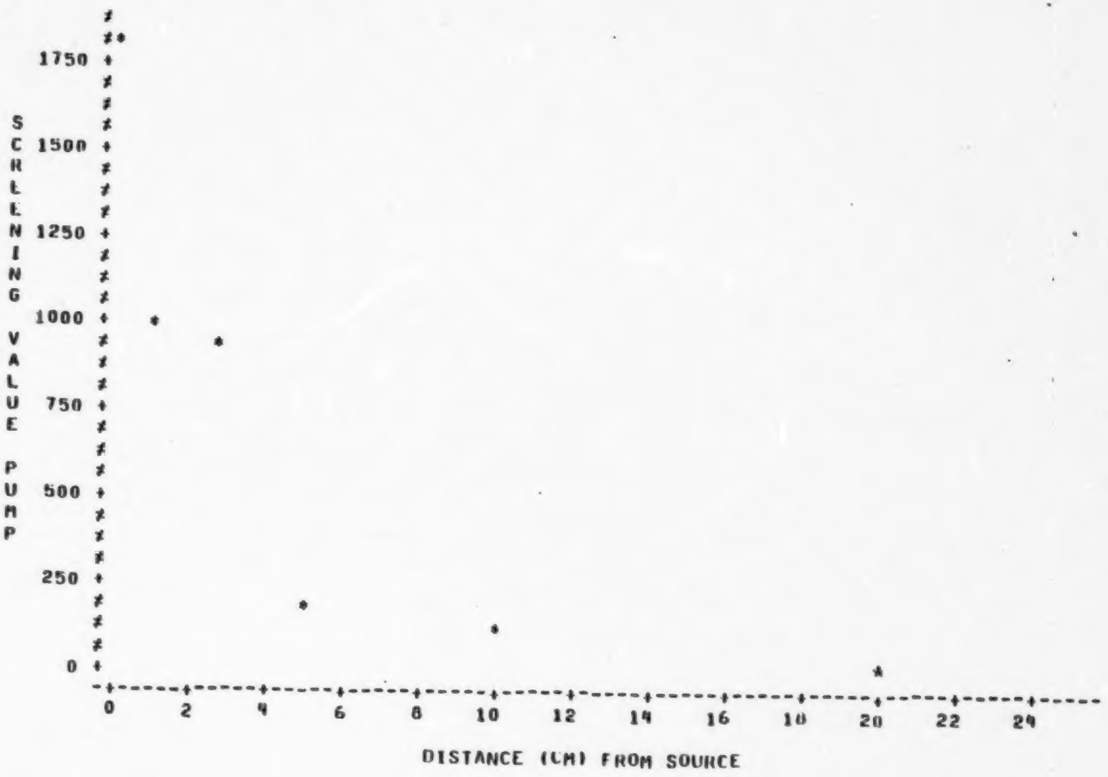


Figure 4-18

RELATIONSHIP OF SCREENING VALUE (PPMV) TO DISTANCE - PUMP

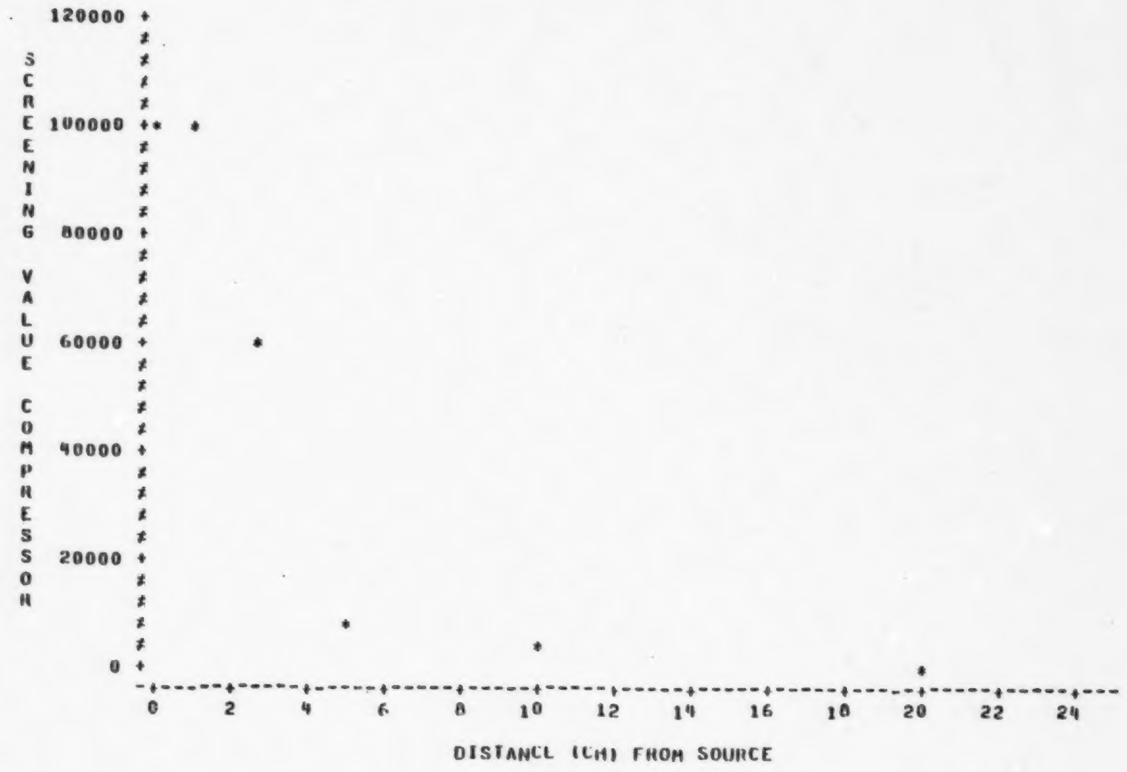


Figure 4-19

RELATIONSHIP OF SCREENING VALUE (PPMV) TO DISTANCE - COMPRESSOR

1. Does the model fit the pump distance screening data?
2. Do all pumps have a common rate of decrease in screening value as the distance increases?
3. Can the screening value at the seal be estimated from a screening value at a distance away from the seal?

Since log $(y_{ij}) = B_o + B_iX_j$, linear methods of analyses were used to test the fit of the model and to estimate and test the equality of the slopes B_i among pumps. An analysis of covariance was performed on 32 pumps for which, at least, four out of six screening values at consecutive distances were obtained. The model was found to fit well, but the pumps were found to have significantly different slopes. When considering a unique slope for each pump, the model explained 91 percent of the variation, while when considering a common slope among pumps, the model explained 75 percent of the variation. Since it is not useful to consider each pump individually and since the model which assumes a common slope explains a large proportion of the variation, the common slope model is used to show the relationship of screening distance to screening value. The fitted equation for the 32 pumps is $y_j = e^{7.724 - 0.364X_j}$. Figure 4-20 shows this modeled relationship. The horizontal axis represents the screening distance (cm) from the source. The vertical axis is the factor by which the screening value is multiplied to yield a predicted screening value at the source. The predicted mean value is plotted, and the 95 percent confidence limits are shown. For the example depicted in Figure 4-20, if a screening value of 1000 ppmv was obtained at a distance of 2.5 cm, then the predicted mean value at the source would be:

$$1000 \text{ ppmv}/0.4 = 2500 \text{ ppmv}$$

with an upper confidence limit of:

$$2.65 * 2500 \text{ ppmv} = 6625 \text{ ppmv}$$

and lower confidence limit of:

$$0.38 * 7500 \text{ ppmv} = 950 \text{ ppmv}$$

The confidence limit factors of 0.38 and 2.65 were based on the standard error of the fitted equation.

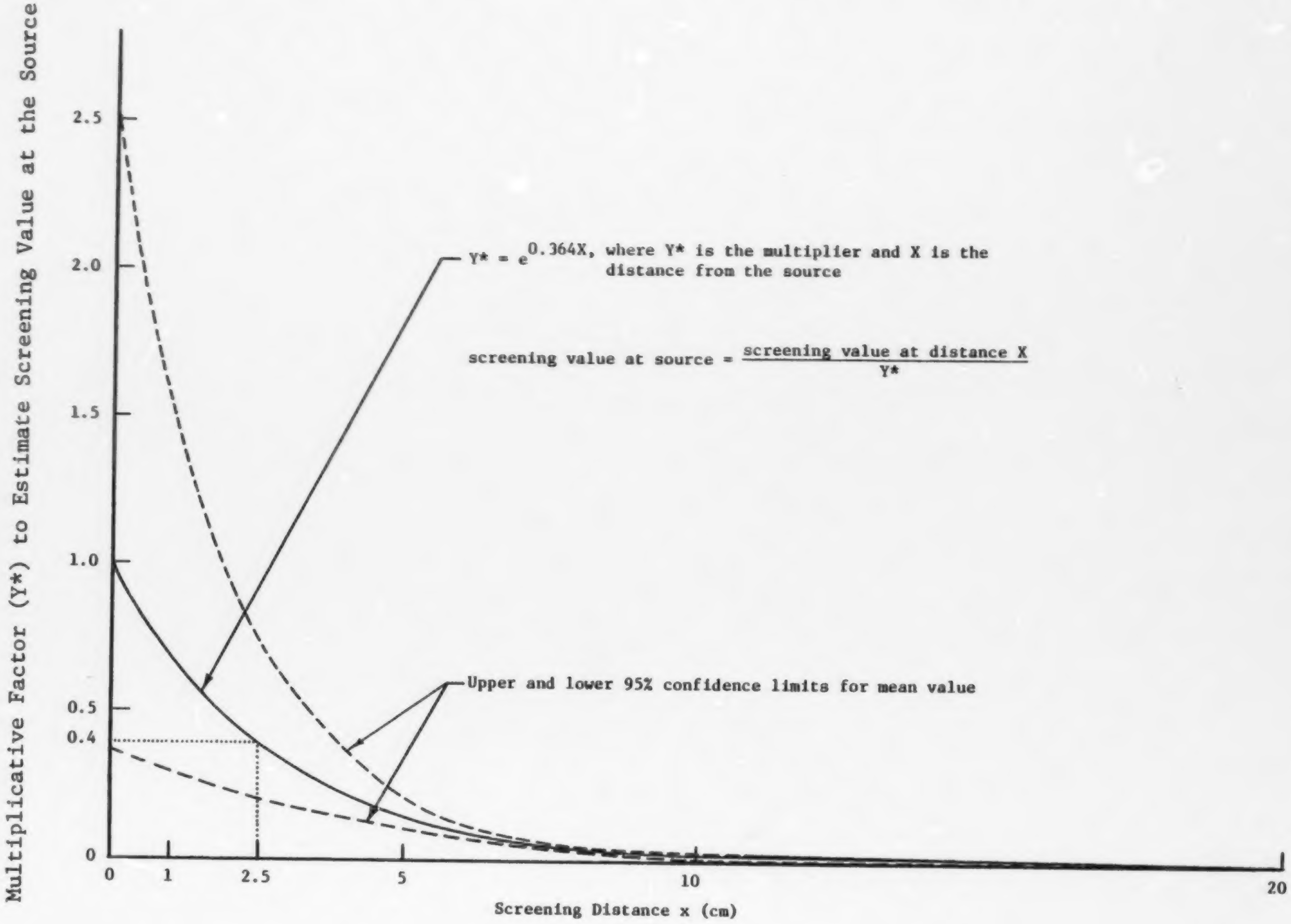


Figure 4-20. Screening Value Multiplier for Varying Screening Distances from Pump Seals

Figures 4-21 through 4-30 compare screening values at the source to screening values at 1 cm, 2.5 cm, 5 cm, 10 cm, and 20 cm for the measured sources. Tables 4-18 and 4-19 show, for pumps and compressors respectively, the percentage of screening values greater than 10,000 ppmv, 1,000 ppmv, and 100 ppmv for each distance for three groups. These groups include sources with screening values at the source in the following ranges: 1,000-9,999 ppmv, 10,000-49,999 ppmv, and 50,000 ppmv and greater.

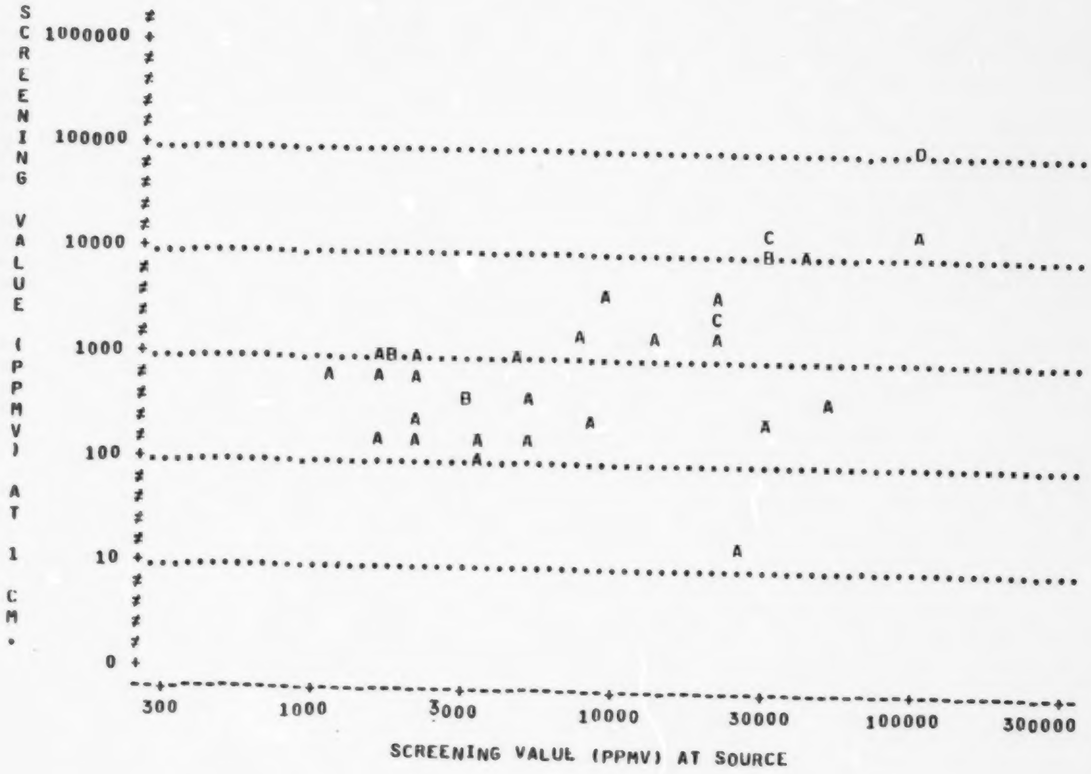


Figure 4-21. Relationship of Screening Value at 1 cm to value at Source - Chevron and Powerine Refinery Pumps

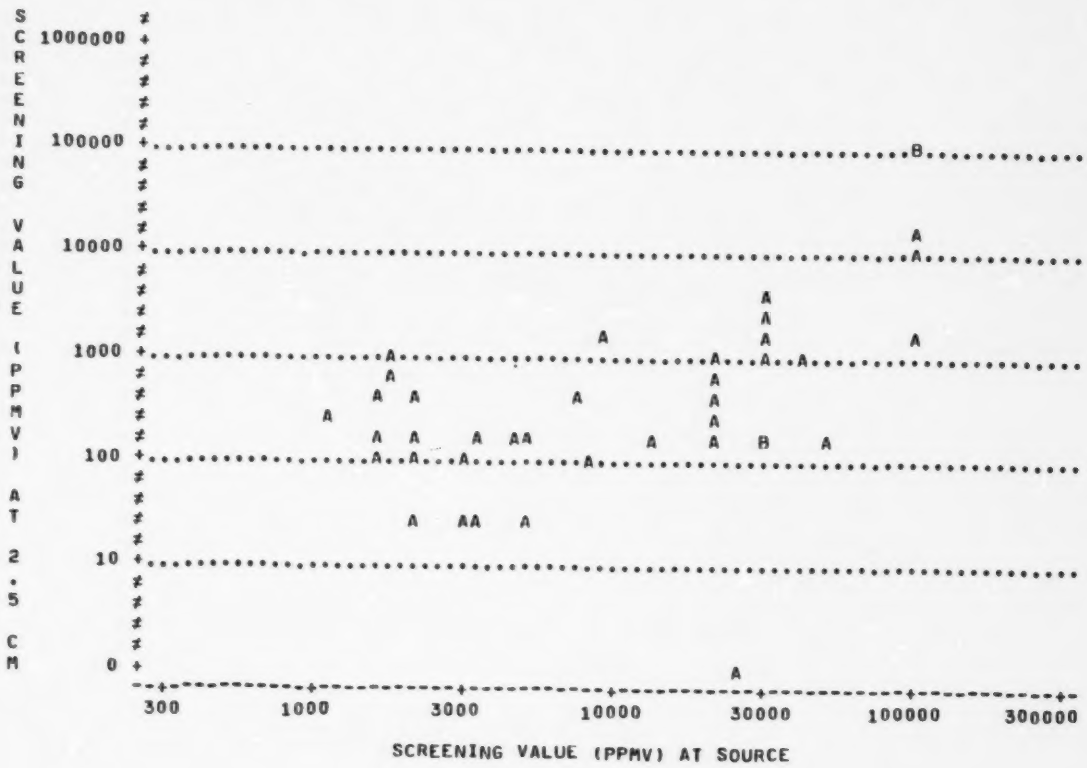


Figure 4-22. Relationship of Screening Value at 2.5 cm to Value at Source - Chevron and Powerine Refinery Pumps

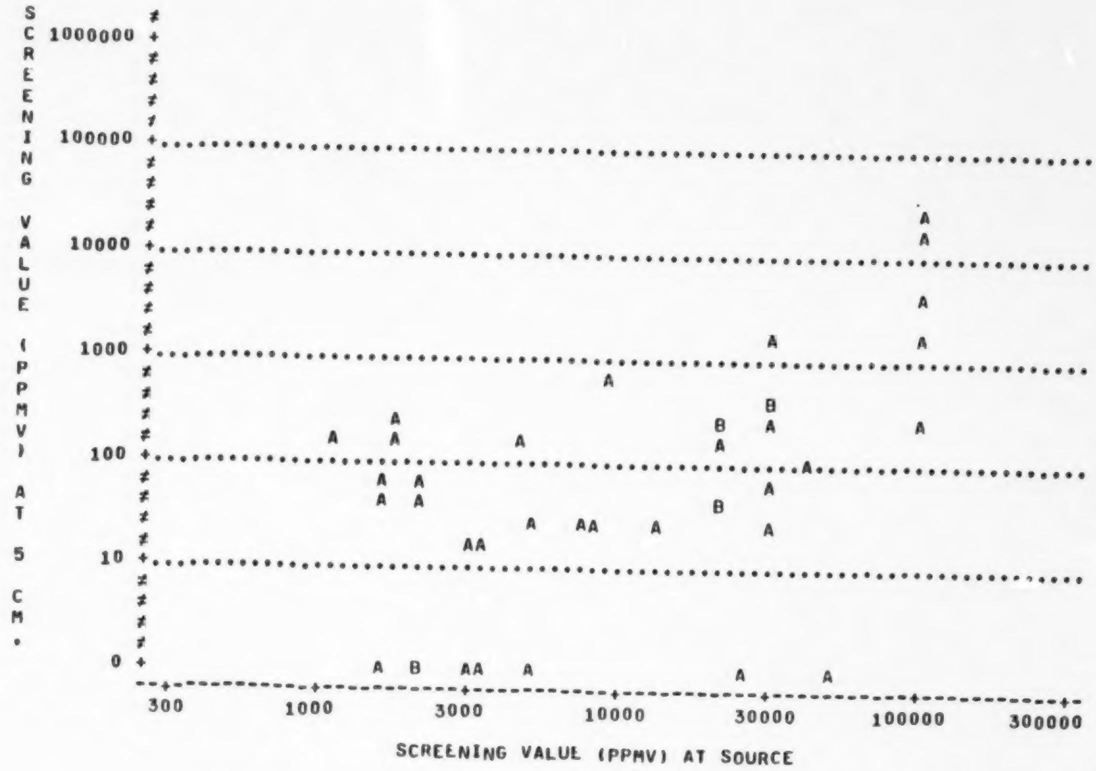


Figure 4-23. Relationship of Screening Value at 5 cm to Value at Source - Chevron and Powerine Refinery Pumps

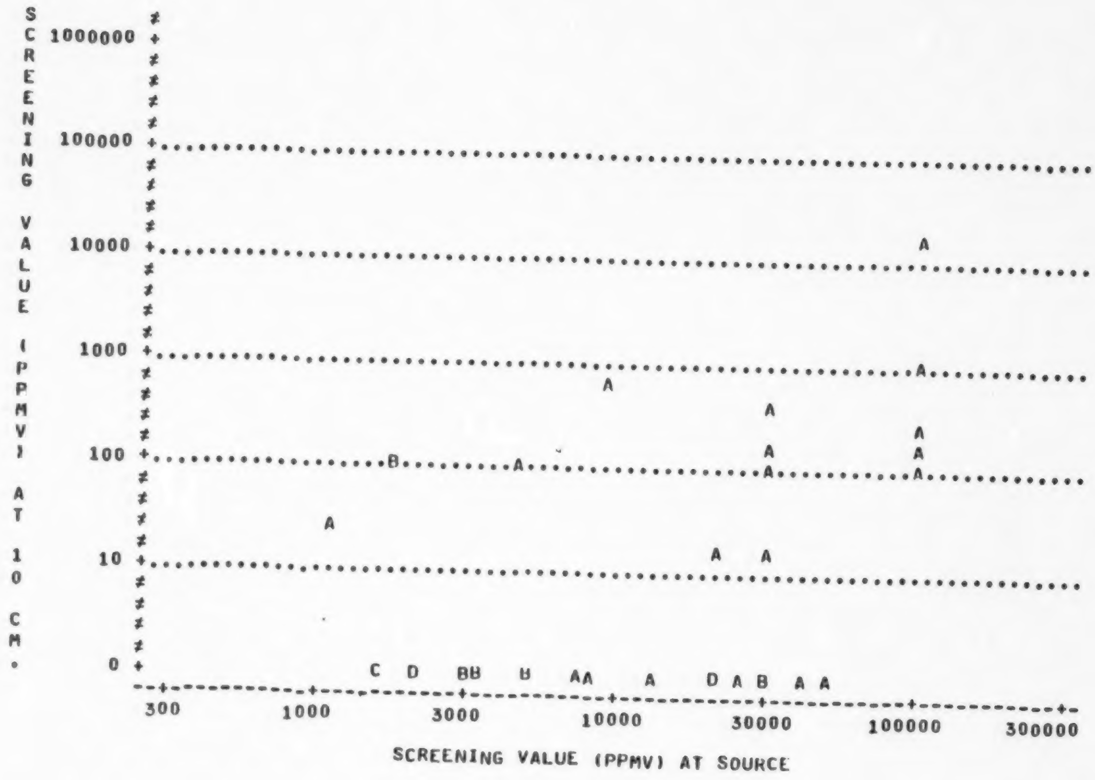


Figure 4-24. Relationship of Screening Value at 10 cm to Value at Source - Chevron and Powerine Refinery Pumps

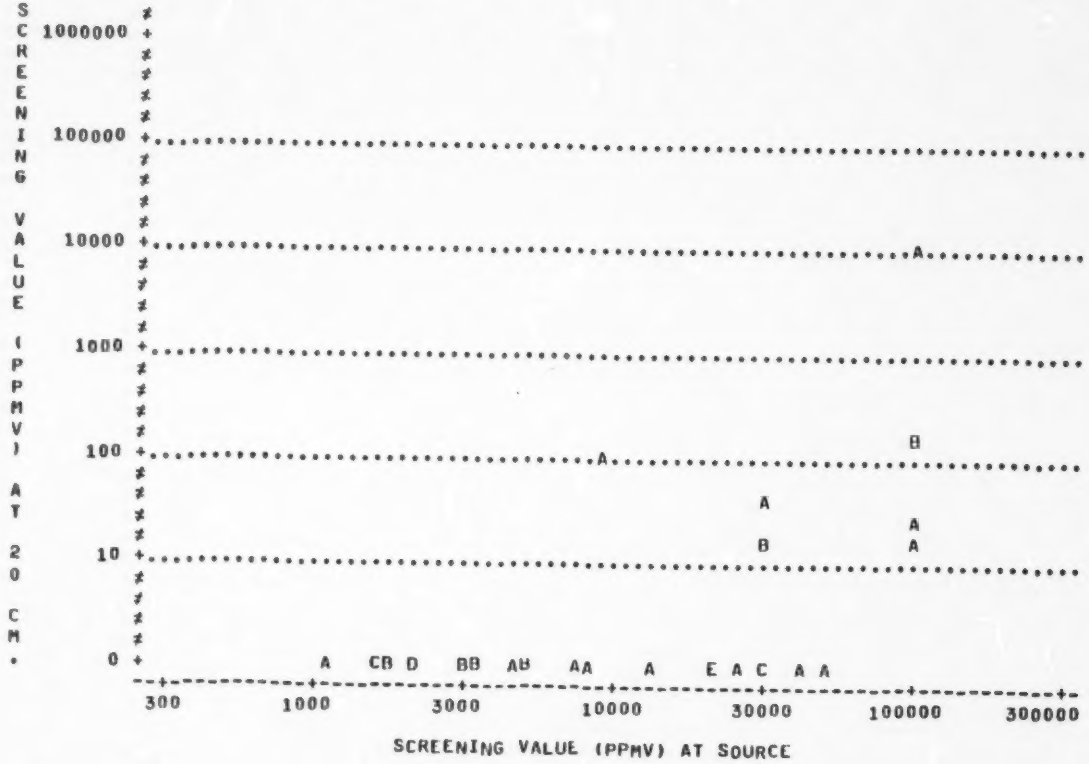


Figure 4-25. Relationship of Screening Value at 20 cm to Value at Source - Chevron and Powerine Refinery Pumps

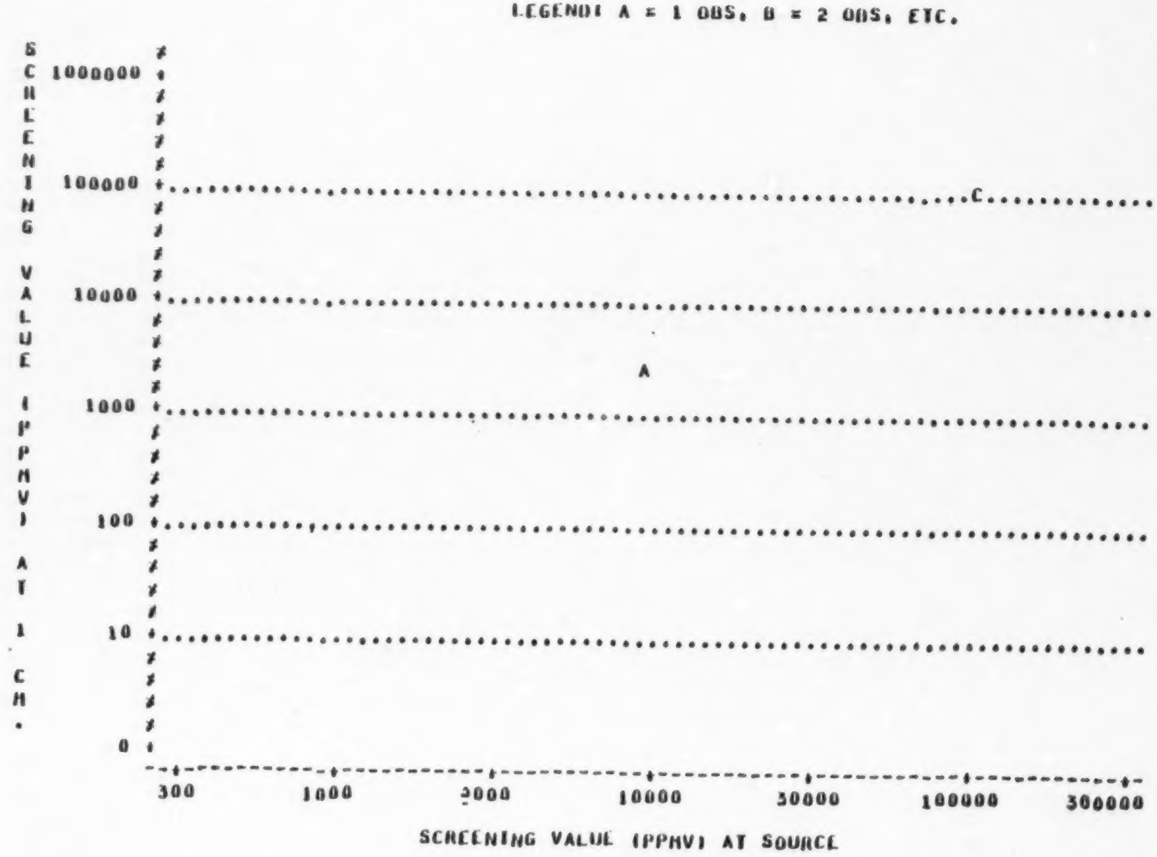


Figure 4-26. Relationship of Screening Value at 1 cm to Value at Source - Chevron and Powerine Refinery Compressors

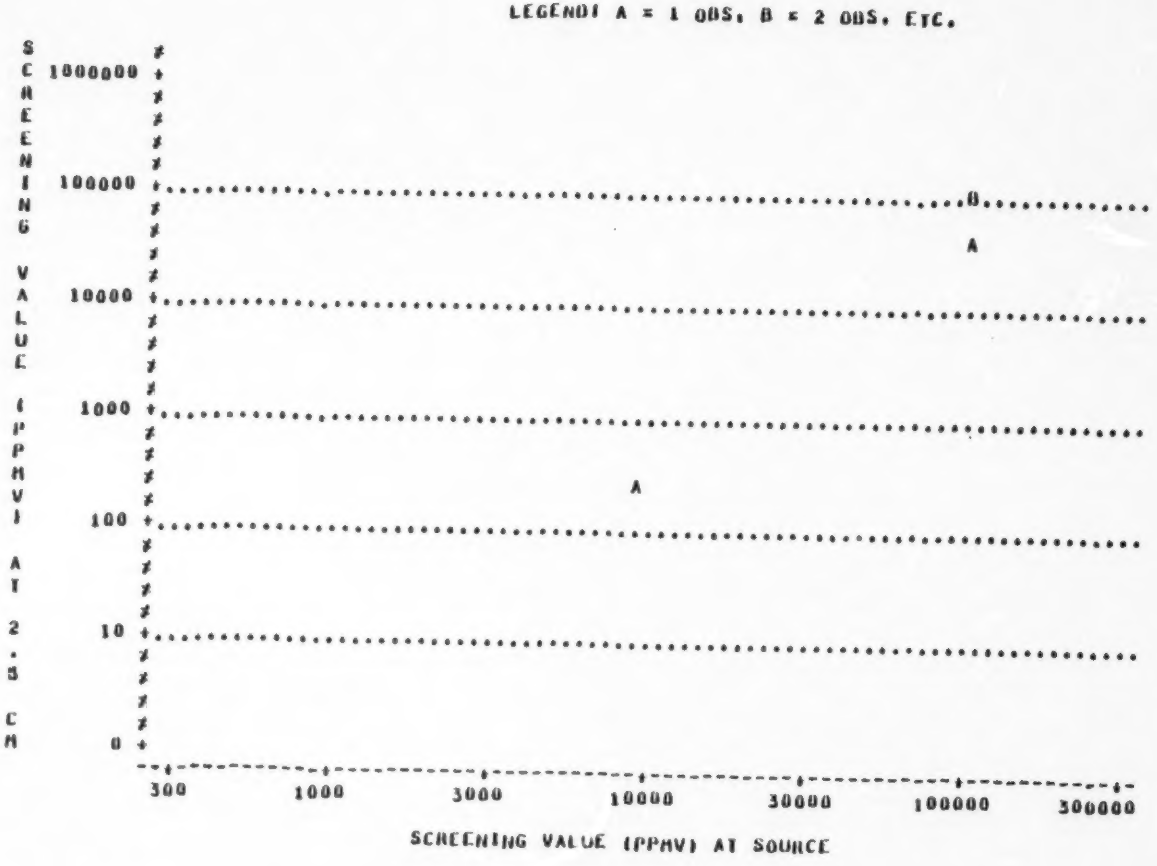


Figure 4-27. Relationship of Screening Value at 2.5 cm to Value at Source - Chevron and Powerine Refinery Compressors

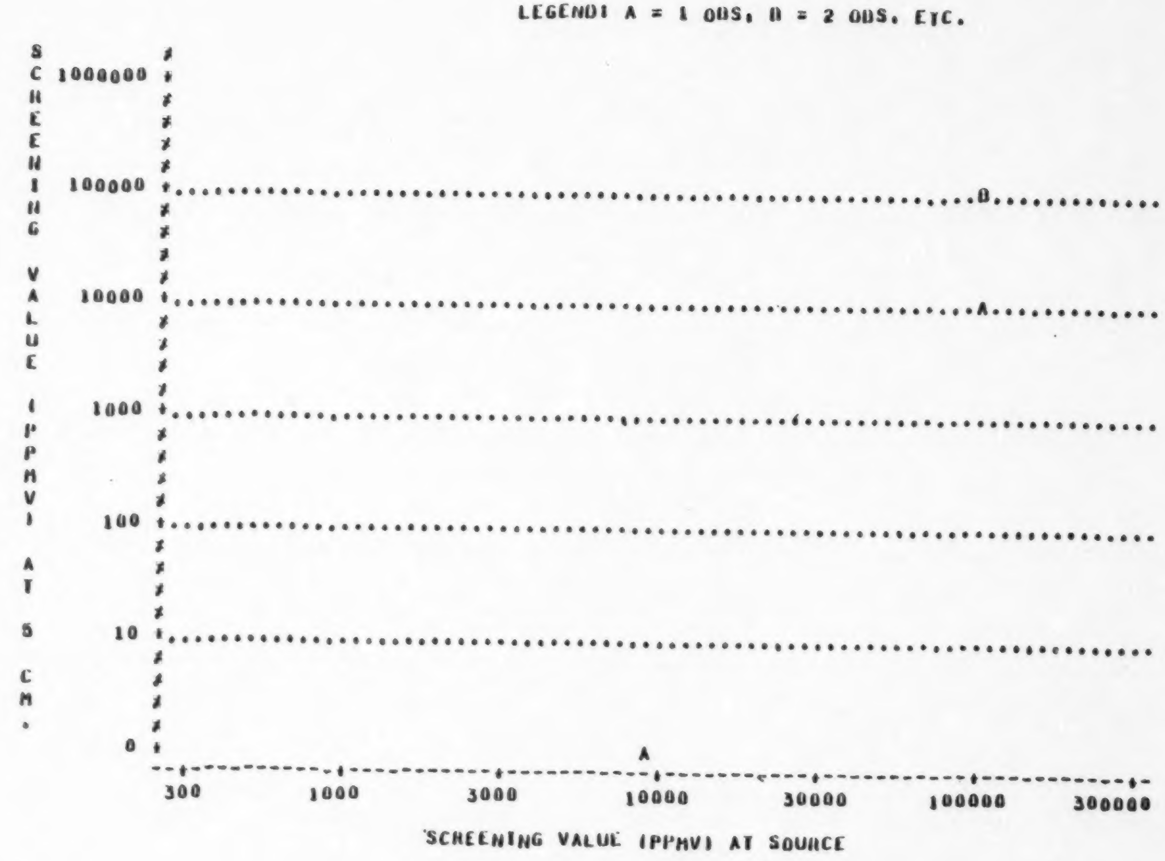


Figure 4-28. Relationship of Screening Value at 5 cm to Value at Source - Chevron and Powerine Refinery Compressors

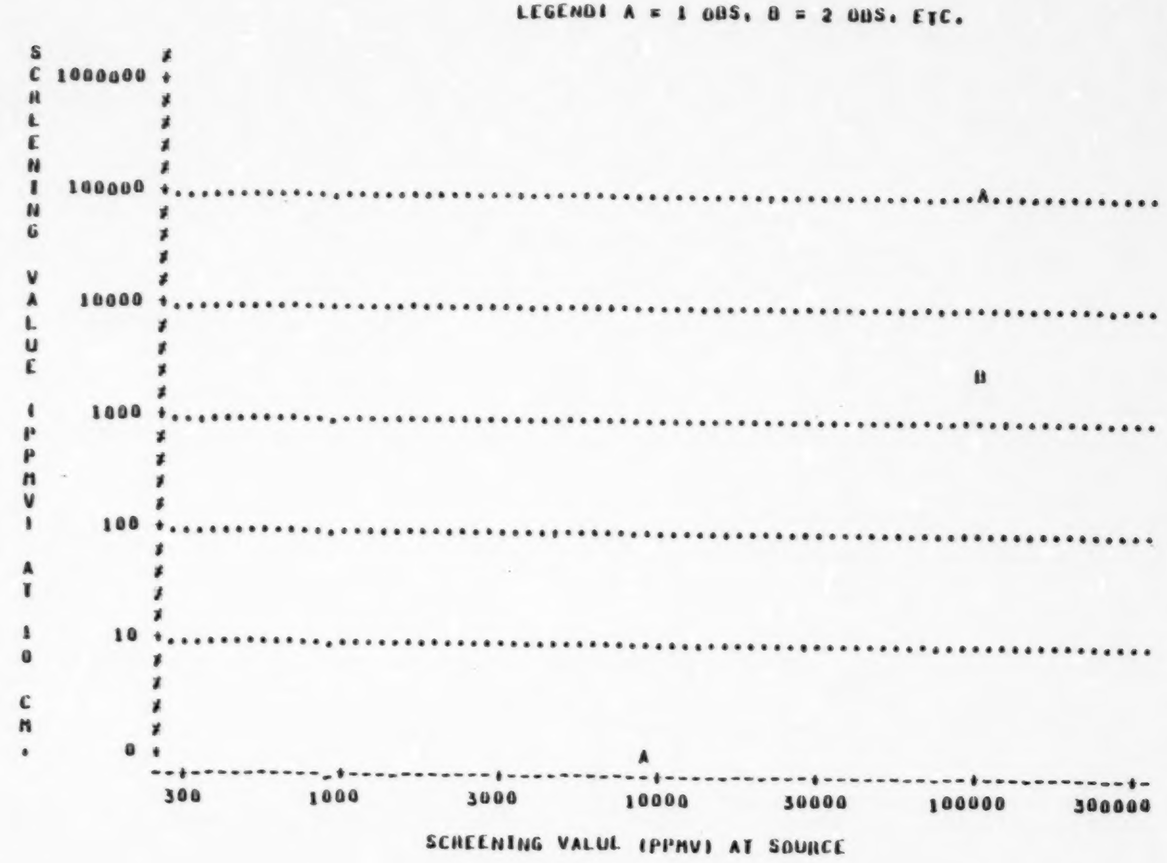


Figure 4-29. Relationship of Screening Value at 10 cm to Value at Source - Chevron and Powerine Refinery Compressors

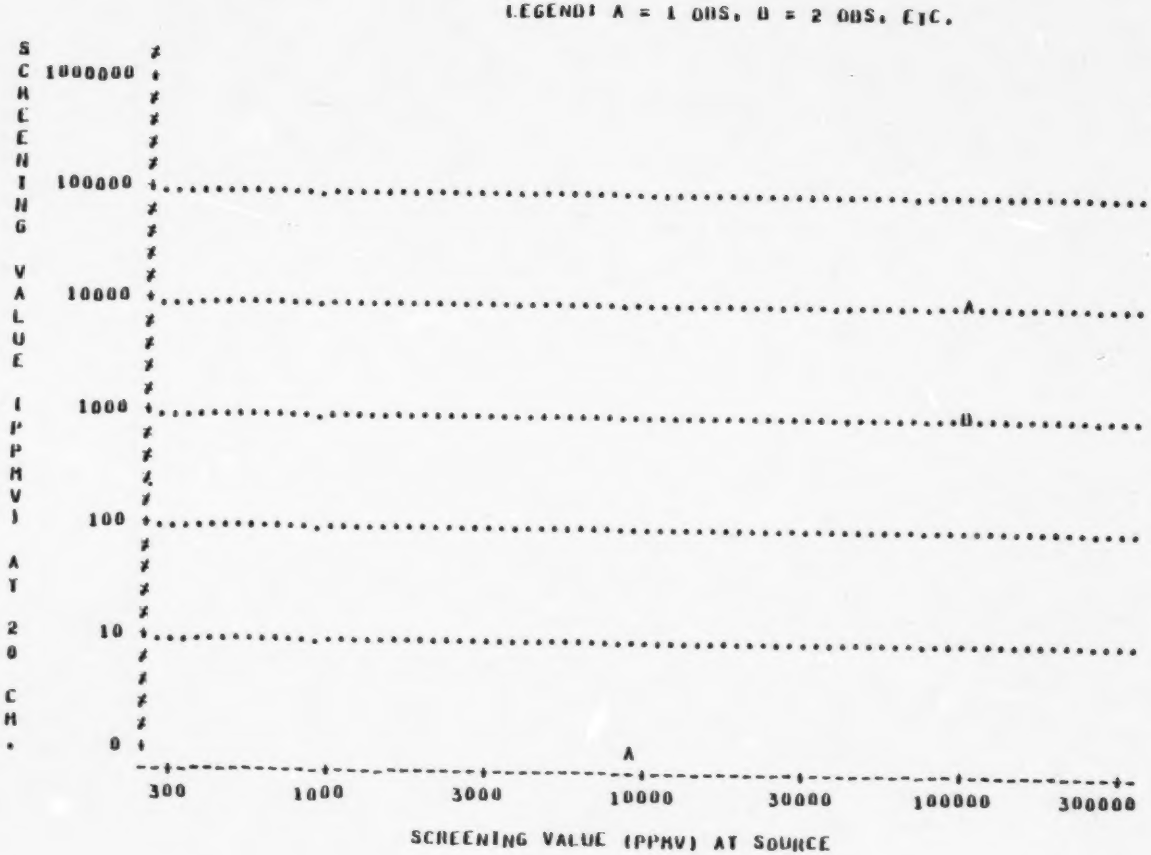


Figure 4-30. Relationship of Screening Value at 20 cm to Value at Source - Chevron and Powerine Refinery Compressors

TABLE 4-18
PERCENTAGE OF SCREENING VALUES >10,000 PPMV, ≥1,000 PPMV, AND ≥100 PPMV FOR EACH DISTANCE

PUMPS

Screening Value at Source (ppmv)	Screening Distance from Source (cm)	% Values ≥10,000	% Values ≥1,000	% Values ≥100
1,000 - 9,999 (20 pumps)	0.0	-	100.0	100.0
	1.0	-	35.0	100.0
	2.5	-	10.0	80.0
	5.0	-	0.0	25.0
	10.0	-	0.0	20.0
	20.0	-	0.0	5.0
10,000 - 49,999 (14 pumps)	0.0	100.0	100.0	100.0
	1.0	42.9	85.7	92.9
	2.5	0.0	42.9	92.9
	5.0	0.0	7.1	57.1
	10.0	0.0	0.0	21.4
	20.0	0.0	0.0	0.0
50,000 and greater (6 pumps)	0.0	100.0	100.0	100.0
	1.0	83.3	83.3	100.0
	2.5	67.7	83.3	100.0
	5.0	33.3	67.7	83.3
	10.0	16.7	33.3	83.3
	20.0	16.7	16.7	50.0

TABLE 4-19
PERCENTAGE OF SCREENING VALUES ≥10,000 PPMV, ≥1,000 PPMV, AND ≥100 PPMV FOR EACH DISTANCE

COMPRESSORS

Screening Value at Source (ppmv)	Screening Distance from Source (cm)	% Values ≥10,000	% Values ≥1,000	% Values ≥100
1,000 - 9,999 (1 compressor)	0.0	-	100.0	100.0
	1.0	-	100.0	100.0
	2.5	-	0.0	100.0
	5.0	-	0.0	0.0
	10.0	-	0.0	0.0
	20.0	-	0.0	0.0
10,000 - 49,999 (0 compressors)				
50,000 and greater (3 compressors)	0.0	100,0	100.0	100.0
	1.0	100.0	100.0	100.0
	2.5	100.0	100.0	100.0
	5.0	100.0	100.0	100.0
	10.0	33.3	100.0	100.0
	20.0	33.0	100.0	100.0

4.5 PUMP SEAL REPLACEMENT DATA

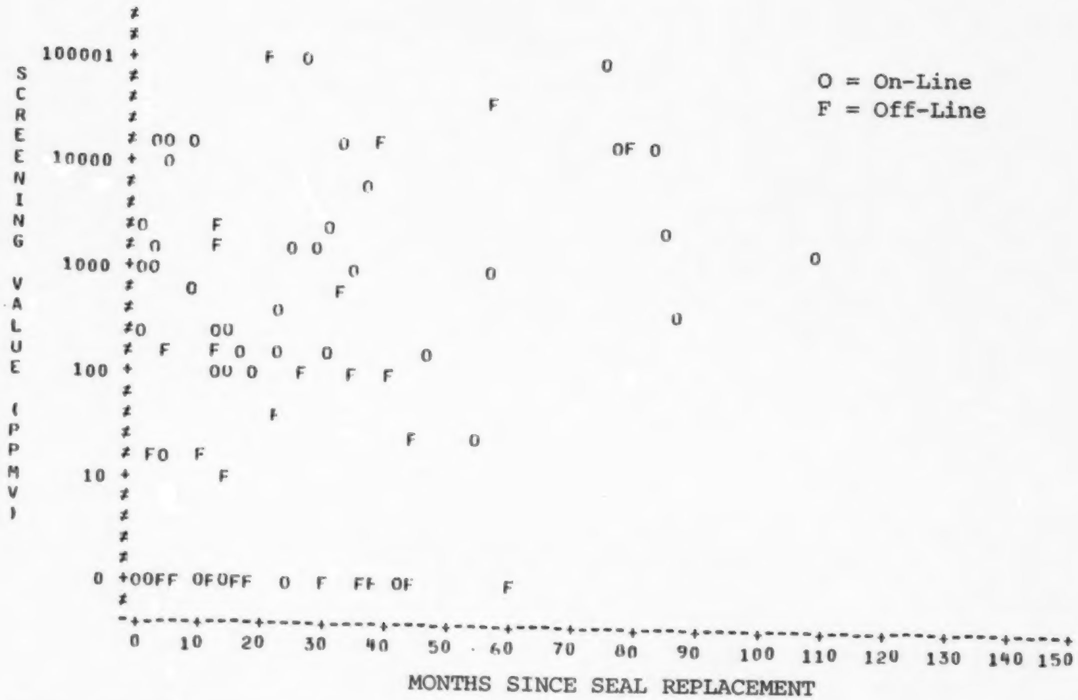
The maintenance history of pump seals was acquired by examining refinery records. The following indicates the total number of screened pumps that had documented seal replacement information:

- light liquid - 86,
- light liquid (exempt) - 11, and
- heavy liquid (exempt) - 12.

Figures 4-31, 4-32, and 4-33 indicate the screening values for these pumps plotted against the length of time since the most recent seal replacement prior to screening. The linear correlation coefficient between screening values and months since the most recent seal replacement is 0.26, which indicates a slight positive relationship (probability of no relationship is less than one percent). The association with time accounts for only 6.8% of the total variation in the screening values. The screening values of the pumps with documented seal replacement data were categorized into four groups as follows:

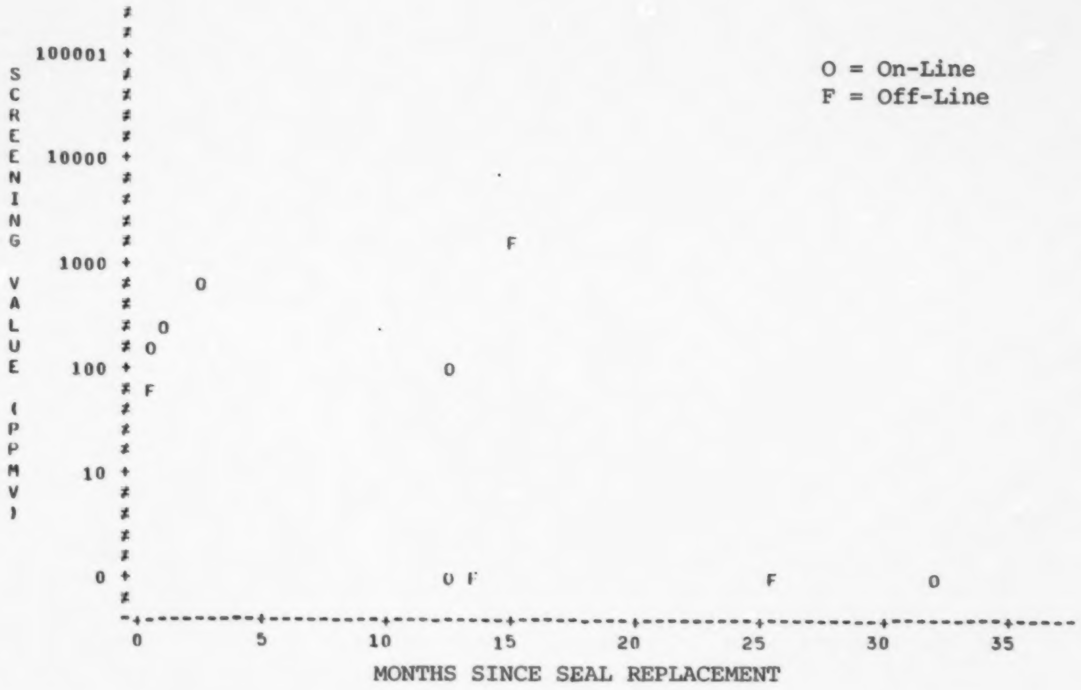
Group	Screening Value (ppmv)	Number of Pumps
1	0-99	53
2	100-999	27
3	1,000-9,999	16
4	$\geq$10,000	13

Figures 4-34, 4-35, and 4-36 indicate the mean, median, and range of the number of months since the most recent seal replacement for pumps in light liquid (subject and exempt) and heavy liquid service, categorized by the four screening value groups. To evaluate the screening value/length of service of seals that are more representative of current technology and practices, records of more recent pump seal replacements (within the last six years) were analyzed (Powerine refinery records of seal replacements dated back only six years). The mean, median, and range of the number of months (within the last



NOTE: 17 OBSERVATIONS HIDDEN

Figure 4-31. Time Since Most Recent Seal Replacement, All Pumps -- Light Liquid.



NOTE: 1 OBSERVATION HIDDEN

Figure 4-32. Time Since Most Recent Seal Replacement, All Pumps -- Light Liquid, Exempt.

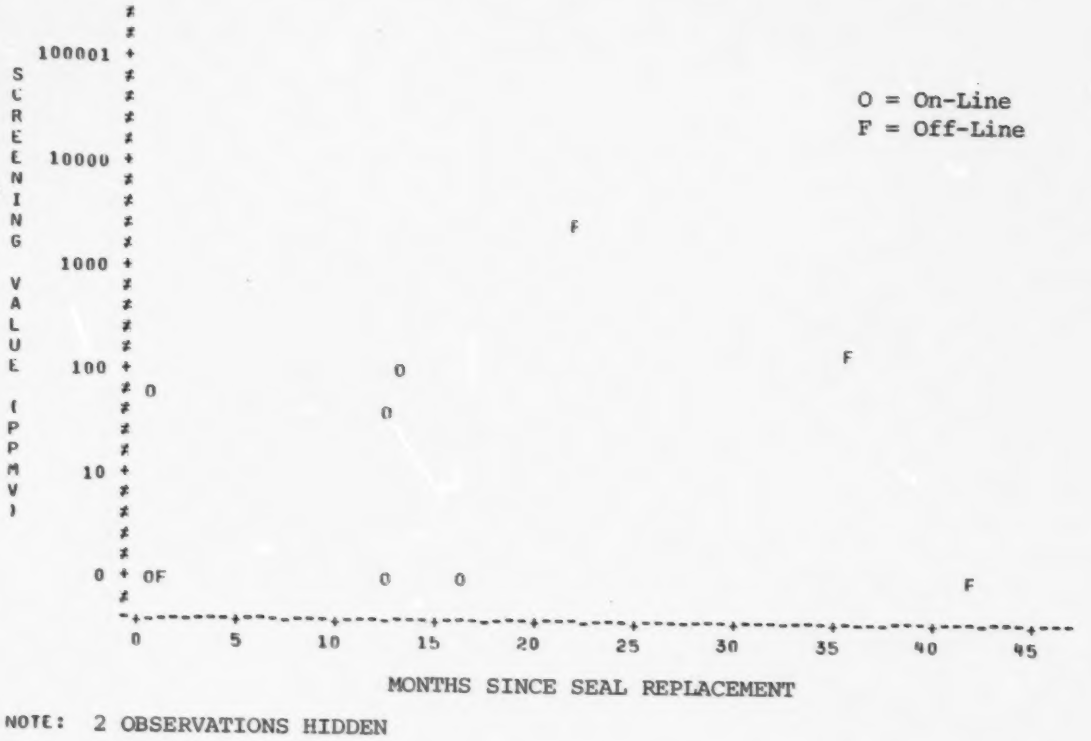


Figure 4-33. Months Since Last Seal Replacement. Heavy Liquid Pumps Exempt from Rule.

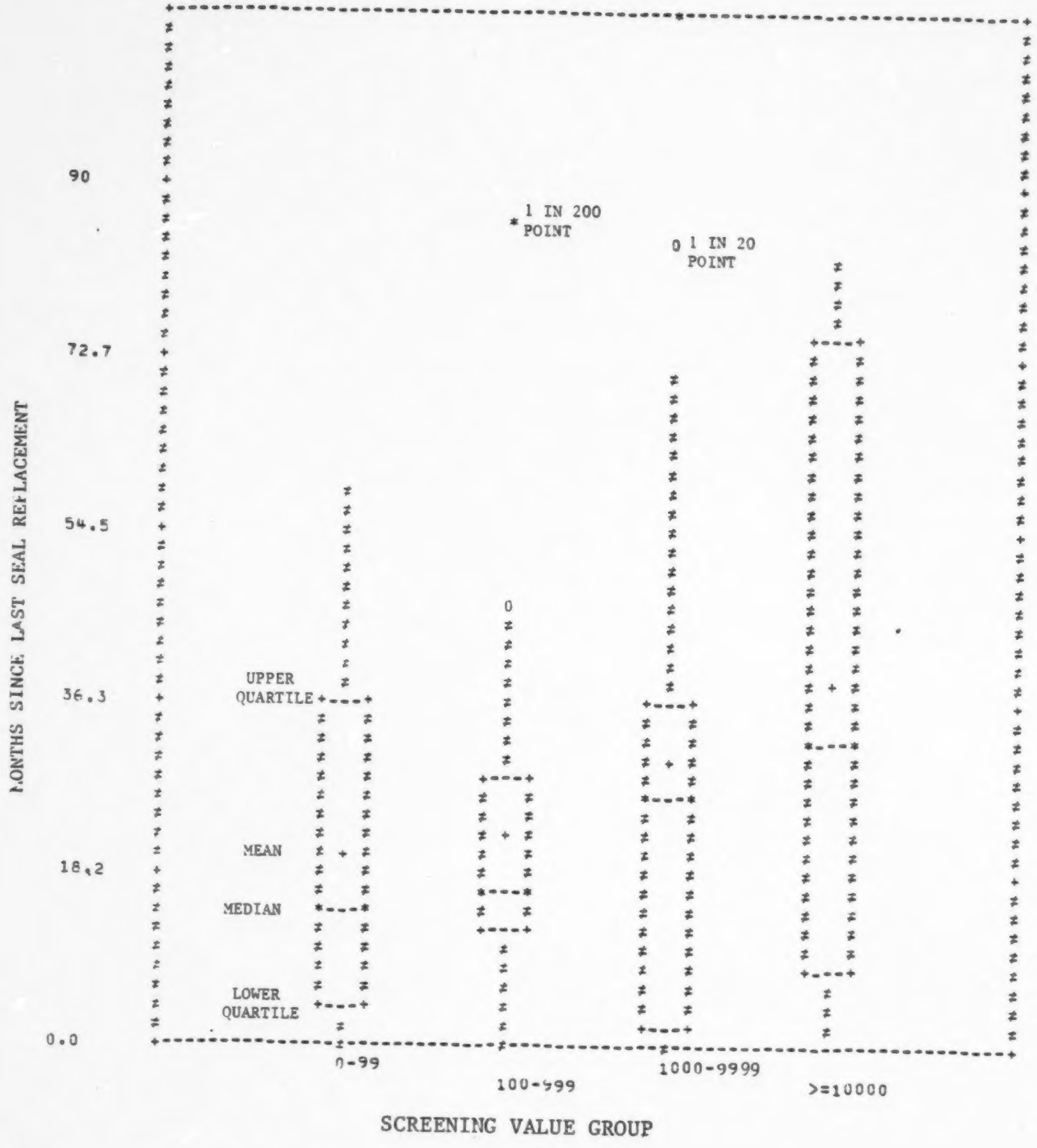


Figure 4-34. Comparison Among Screening Value Groups of Time Since Most Recent Seal Replacement, All Pumps -- Light Liquid, Subject (all years)

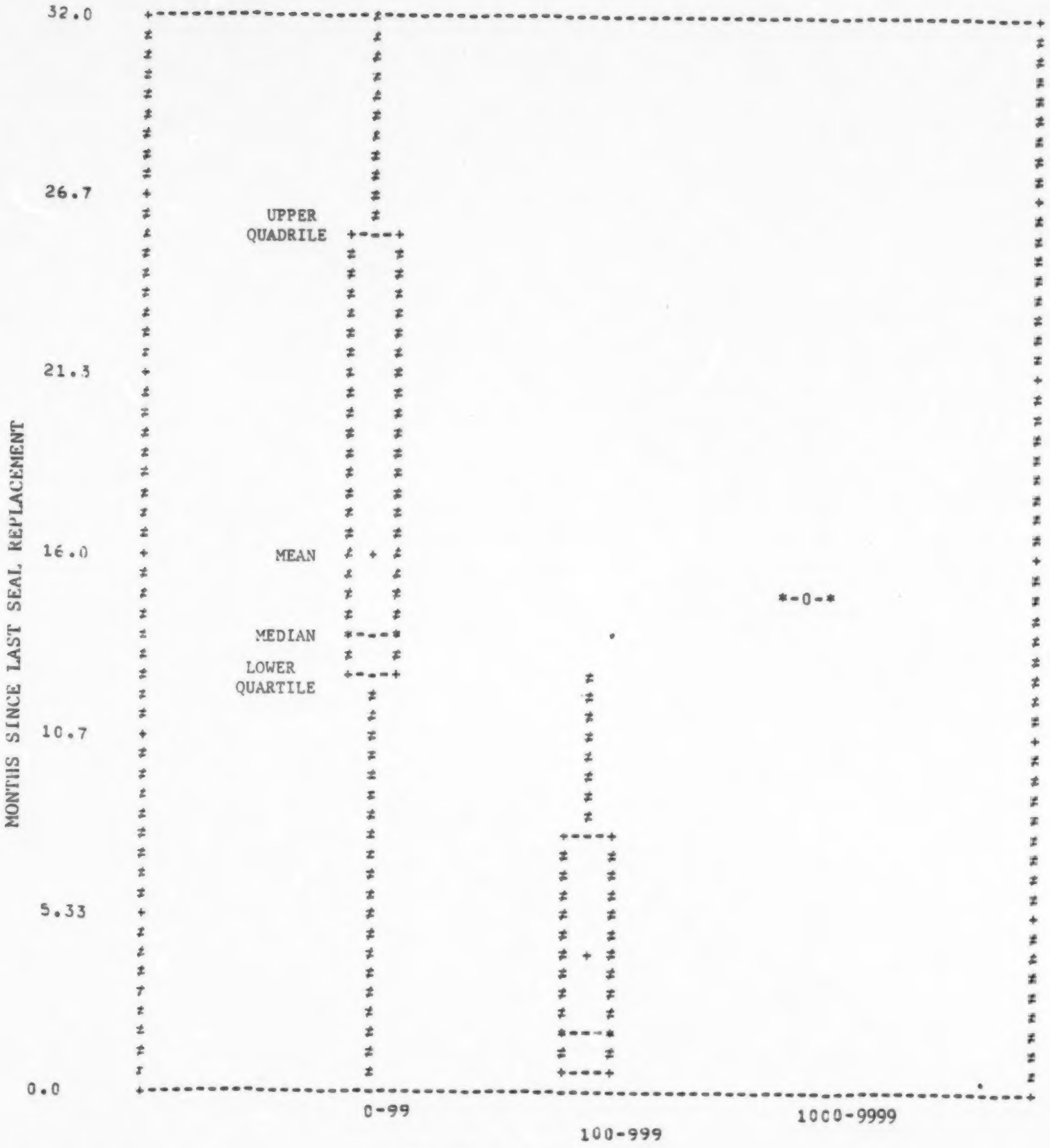


Figure 4-35. Comparison Among Screening Value Groups of Time Since Most Recent Seal Replacement, All Pumps — Light Liquid, Exempt (all years)

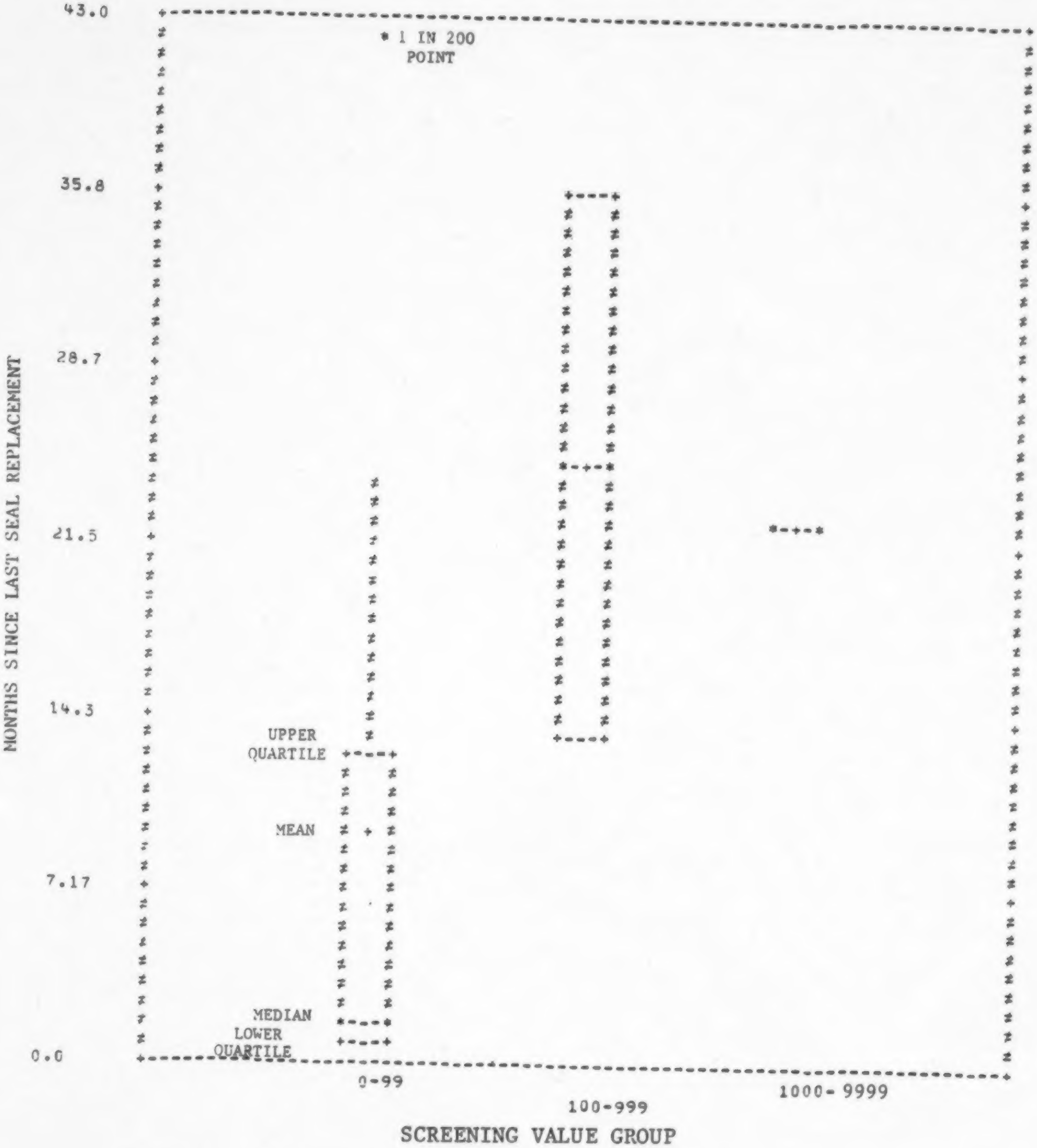


Figure 4-36. Comparison Among Screening Value Groups of Time Since Most Recent Seal Replacement, All Pumps -- Heavy Liquid Exempt from Rule

six years) since the most recent seal replacement for pumps in light liquid (subject) service are shown in Figure 4-37 for the four screening categories. All documented seal replacements for pumps in light liquid (exempt) and heavy liquid service occurred within the last six years, so more recent relationships between screening values and time since last seal replacement are the same as those shown earlier in Figures 4-35 and 4-36.

The available historical data at the two refineries indicated that 544 seals had been replaced in 98 pumps. The intervals between replacement of these pump seals were determined from two successive dates of seal replacement. Intervals between replacement that could not be determined accurately because of inadequate documentation were omitted from analysis. Figures 4-38 and 4-39 categorize, by percentage, intervals between pump seal replacements at the Chevron and Powerine refineries, respectively. These figures represent all available documented seal replacement data. Composite results of intervals between pump seal replacements at both refineries within the last six years is shown in Figure 4-40. Figures 4-41, 4-42, and 4-23 show the same results of pump seal replacement intervals on a cumulative basis.

The numbers of pump seals replaced each year at the Chevron and Powerine refineries are shown in Figures 4-44 and 4-45, respectively. Records for 1981 include only those pump seals replaced in the first three months of the year.

A mean interval between pump seal replacements was determined for each pump by examining individual pump maintenance histories. Mean seal replacement intervals for the pumps analyzed at the Chevron and Powerine refineries are categorized by percentage in Figures 4-46 and 4-47, respectively. These results are presented on a cummulative basis in Figures 4-48 and 4-49. Figures 4-50 and 4-51 represent percentages and cummulative percentages for intervals between seal replacement of pumps at both refineries.

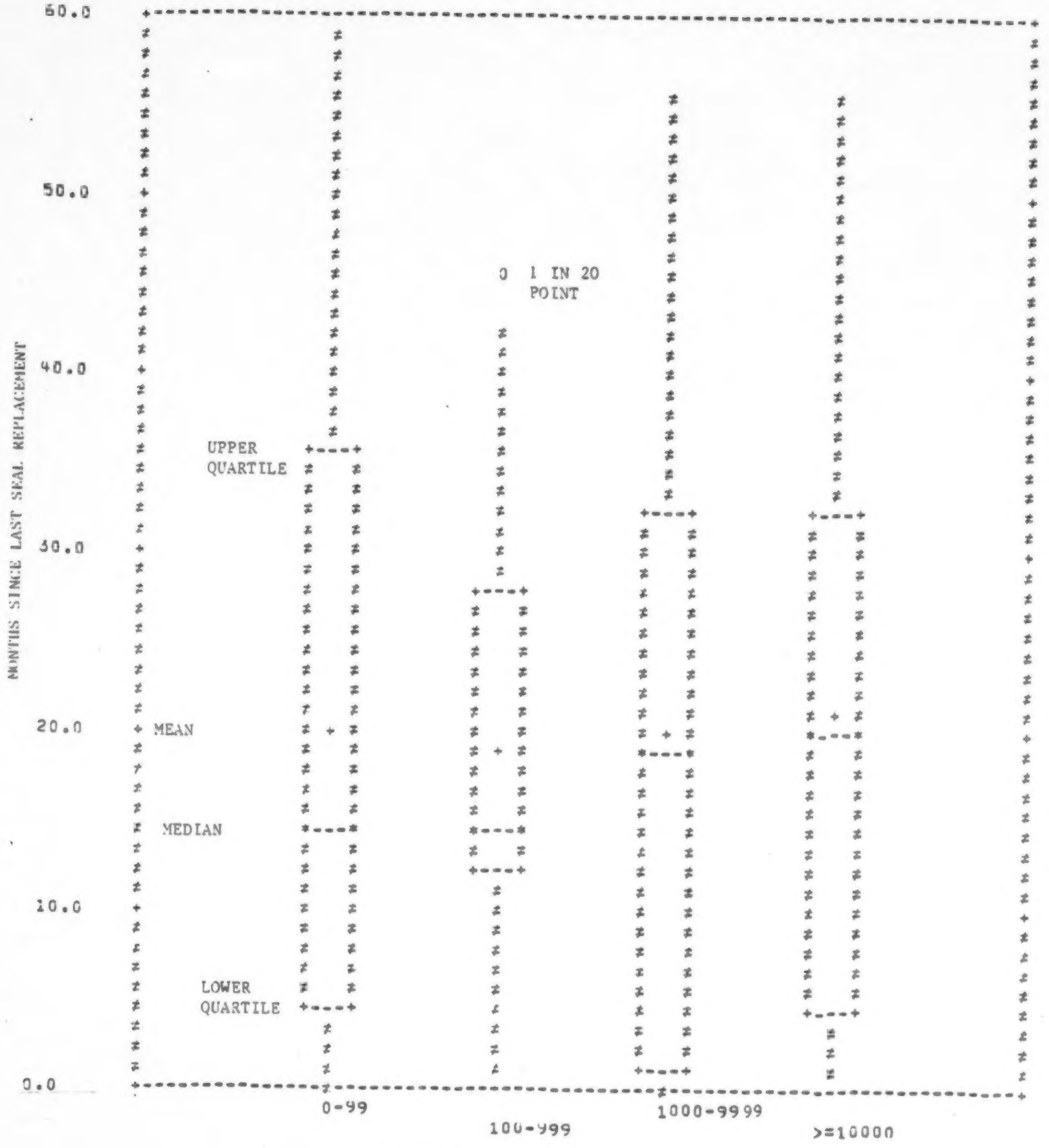


Figure 4-37. Comparison Among Screening Value Groups of Time Since Most Recent Seal Replacement, All Pumps -- Light Liquid, Subject (Last Six Years)

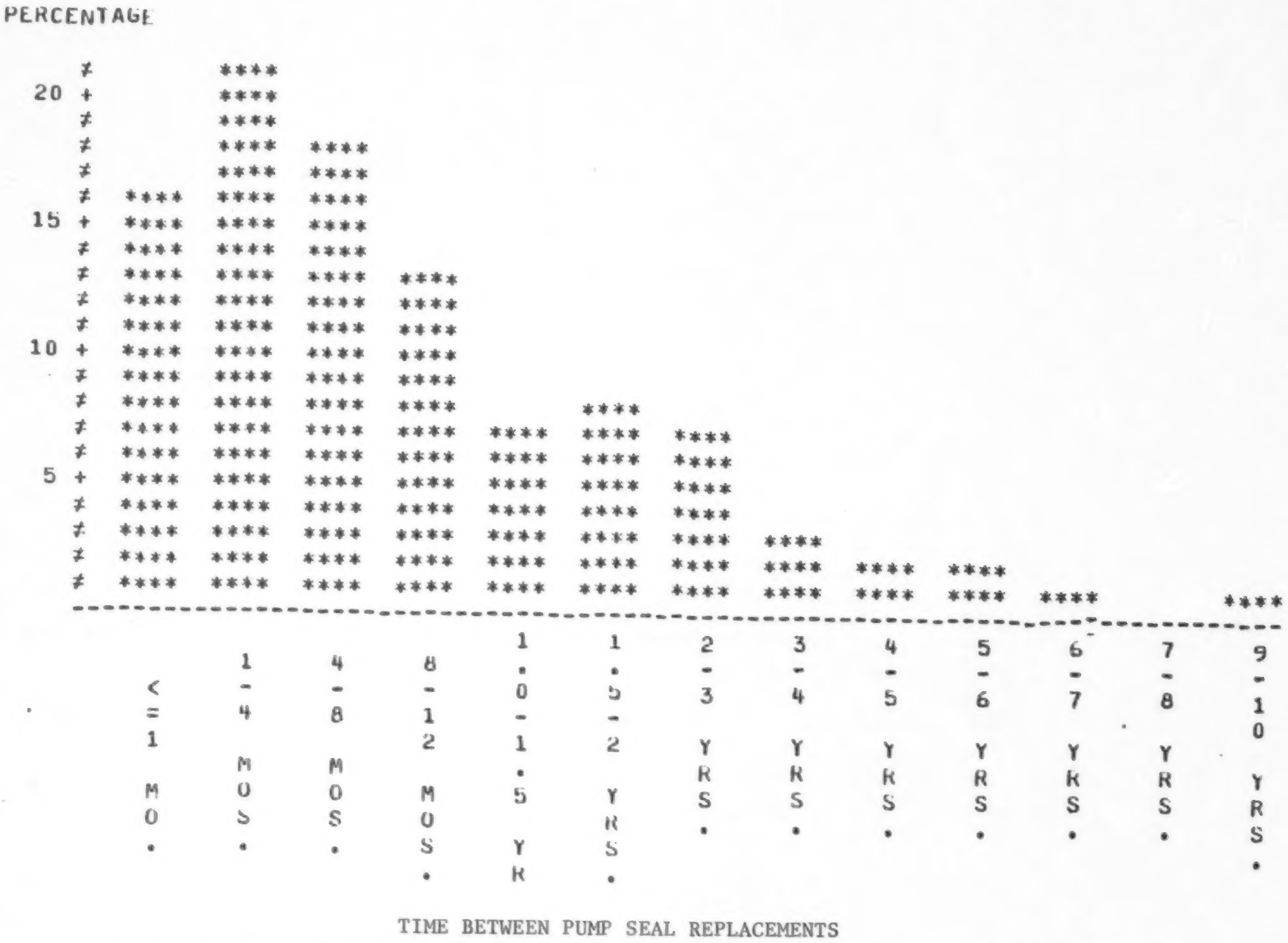
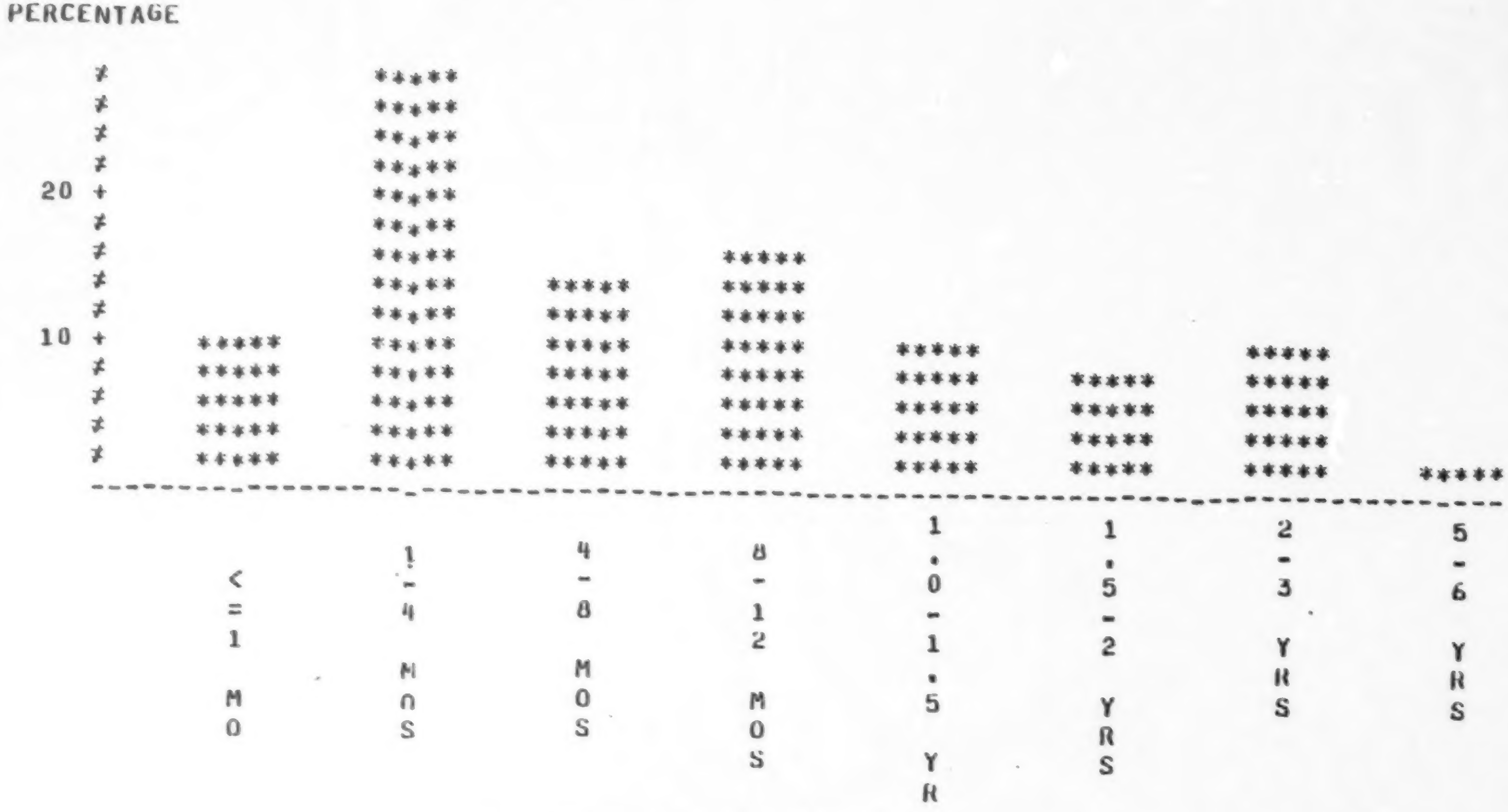


Figure 4-38. Intervals Between Chevron Refinery Pump Seal Replacements (Percentage), All Years



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PERCENTAGE

    I               *****
    I               *****
    I               *****
    I               *****
 20 +               *****
    I               *****
    I               *****               *****
    I               *****     *****     *****
    I               *****     *****     *****
 10 +     *****     *****     *****     *****     *****               *****
    I     *****     *****     *****     *****     *****     *****     *****
    I     *****     *****     *****     *****     *****     *****     *****
    I     *****     *****     *****     *****     *****     *****     *****
    I     *****     *****     *****     *****     *****     *****     *****     *****
    ---------------------------------------------------------------------------------
                                                    1         1         2         5
                      1         4         8         .         .         -         -
            <         -         -         -         0         5         3         6
            =         4         8         1         -         -
            1                             2         1         2         Y         Y
                      M         M                   .                   R         R
            M         O         O         M         5         Y         S         S
            O         S         S         O                   R
                                          S         Y         S
                                                    R
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TIME BETWEEN PUMP SEAL REPLACEMENTS

Figure 4-39. Intervals Between Powerine Refinery Pump Seal Replacements (Percentage), All Years

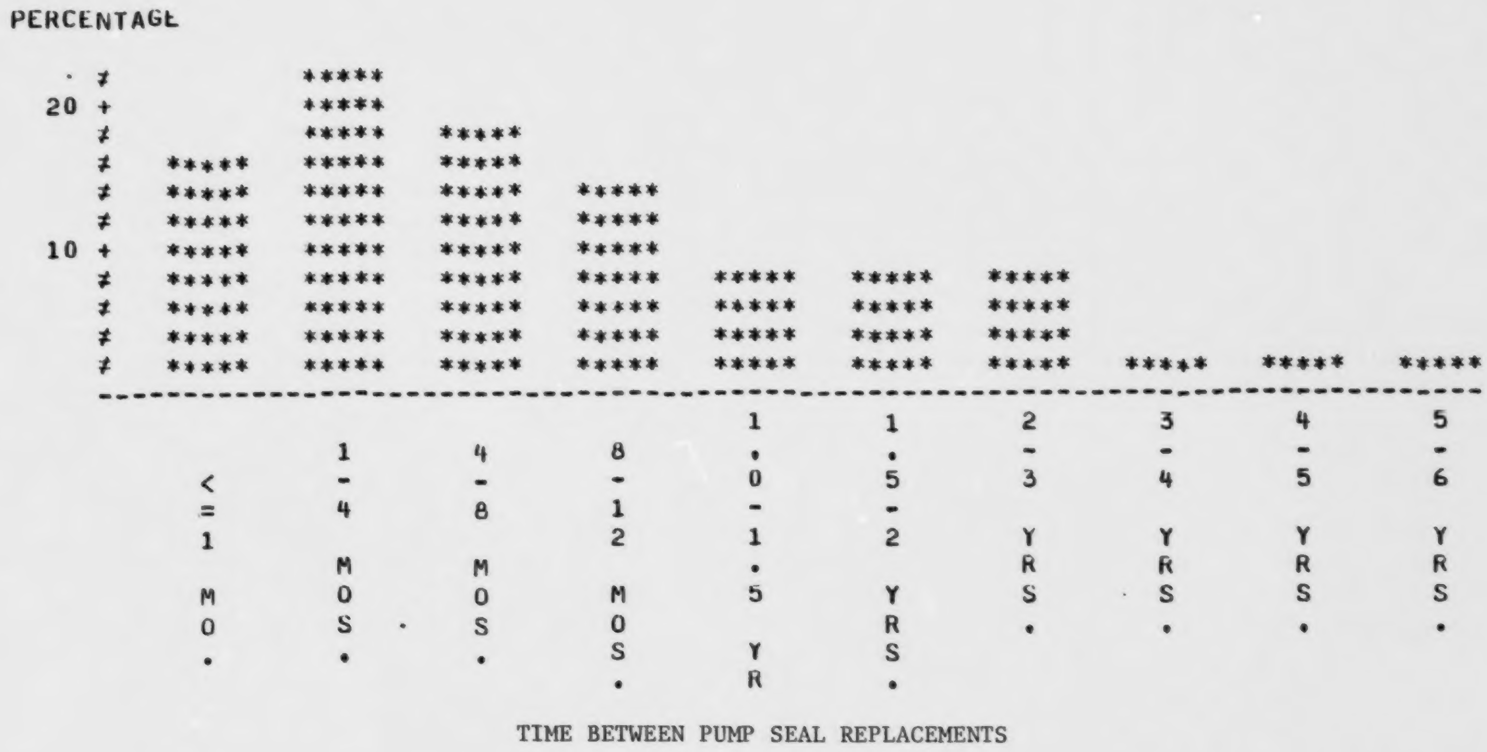


Figure 4-40. Intervals Between Chevron And Powerline Refinery Pump Seal Replacements (Percentage), Last Six Years

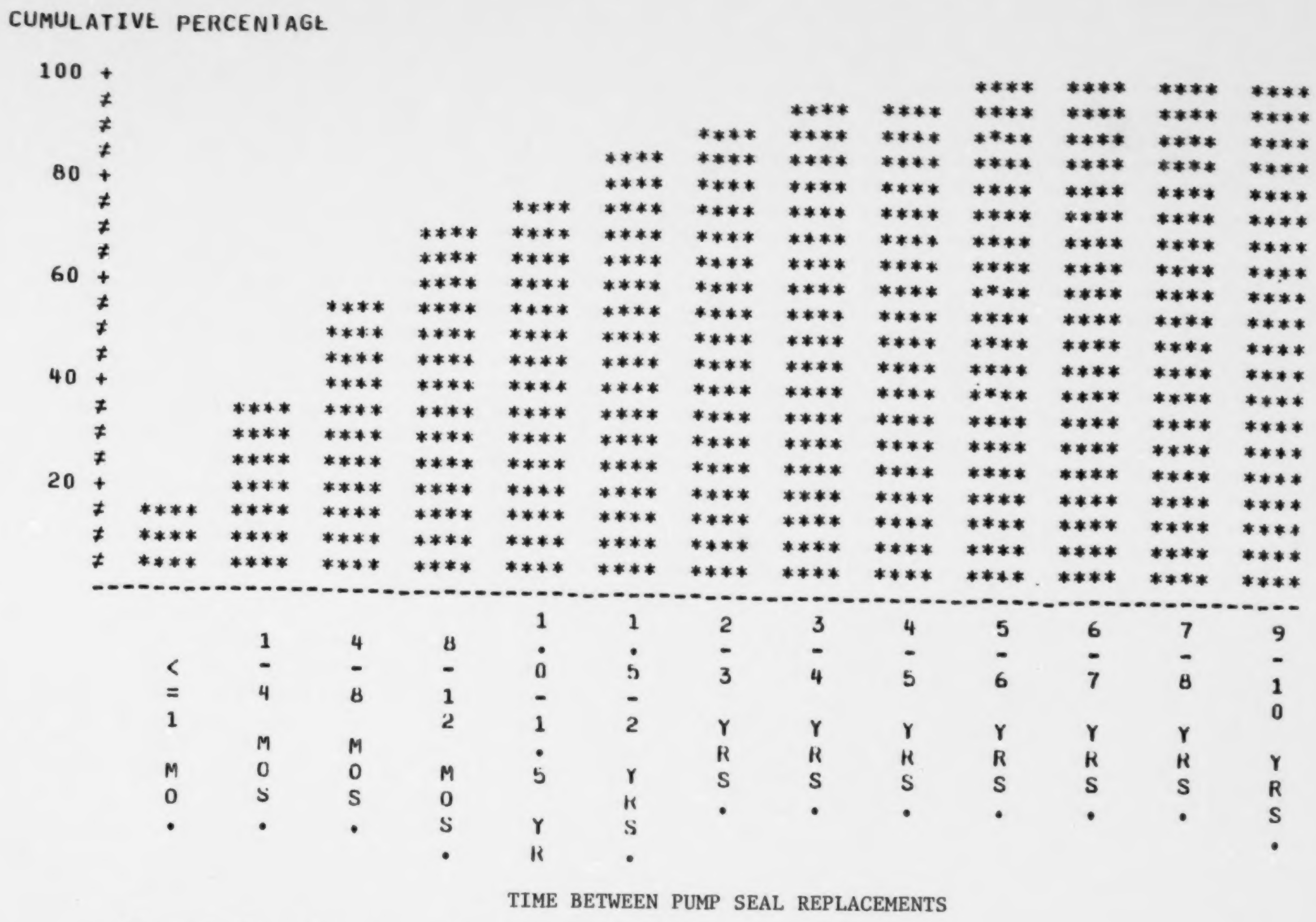


Figure 4-41. Intervals Between Chevron Refinery Pump Seal Replacements (Cumulative Percentage), All Years

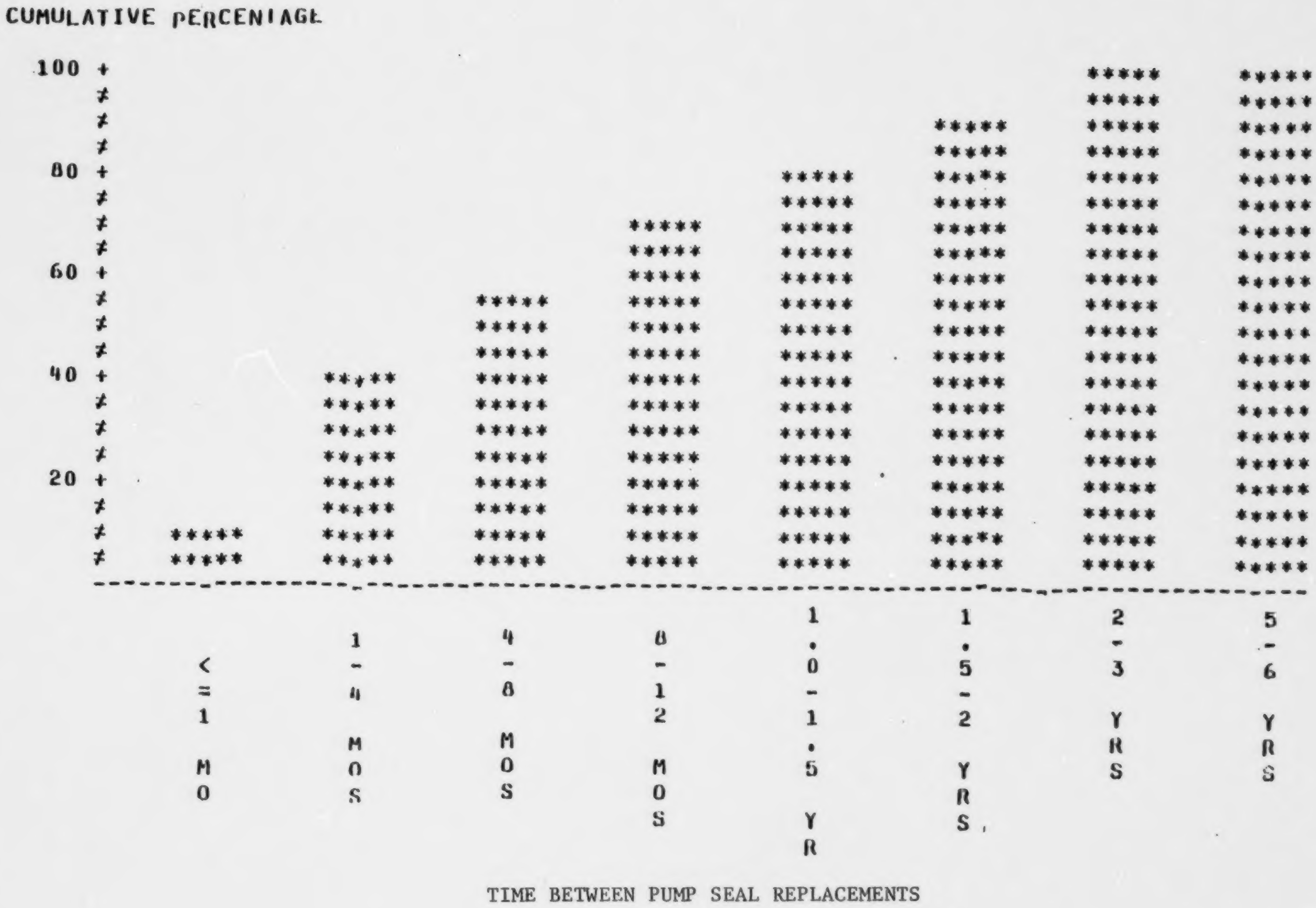


Figure 4-42. Intervals Between Powerline Refinery Pump Seal Replacements (Cumulative Percentage), All Years

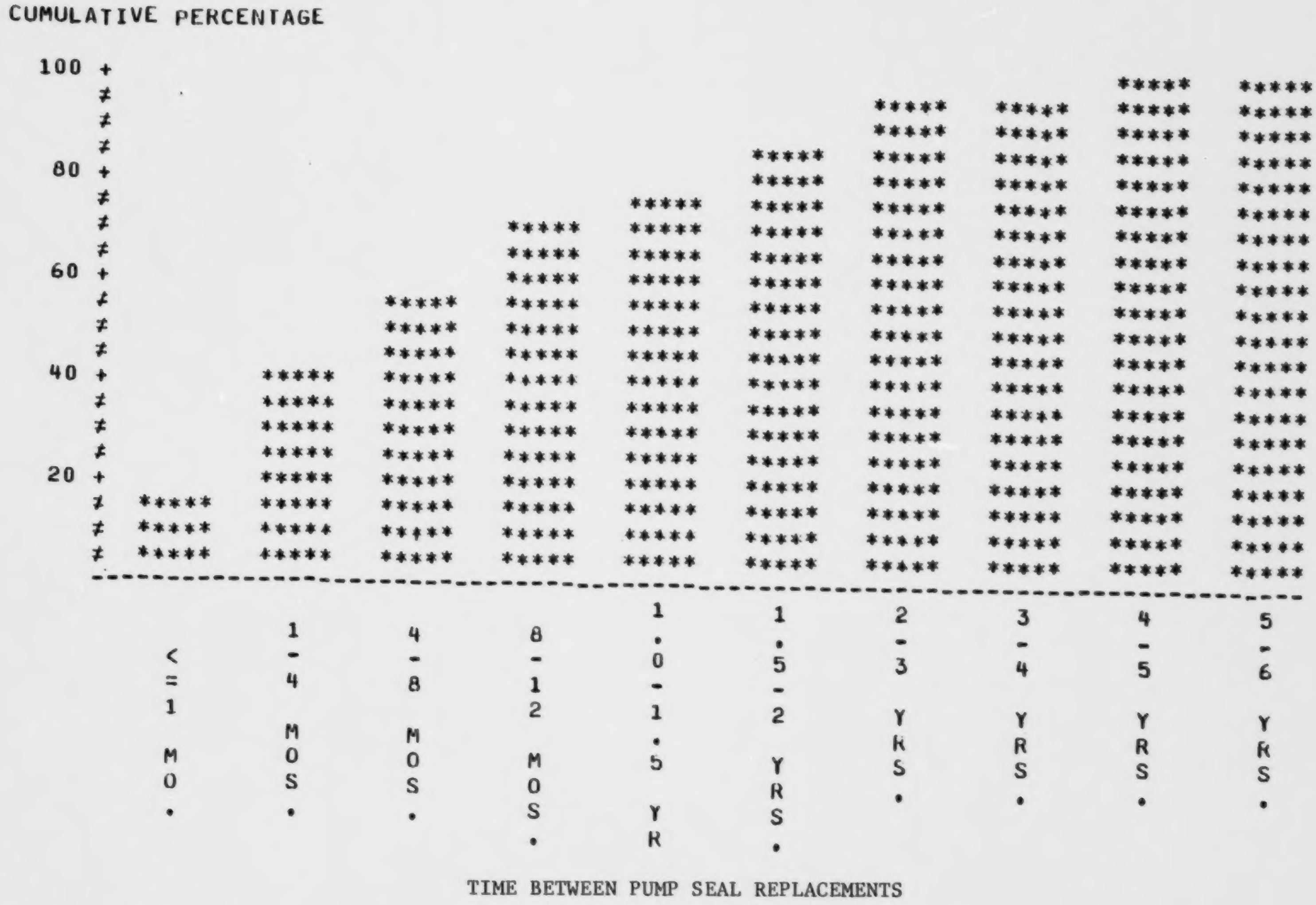
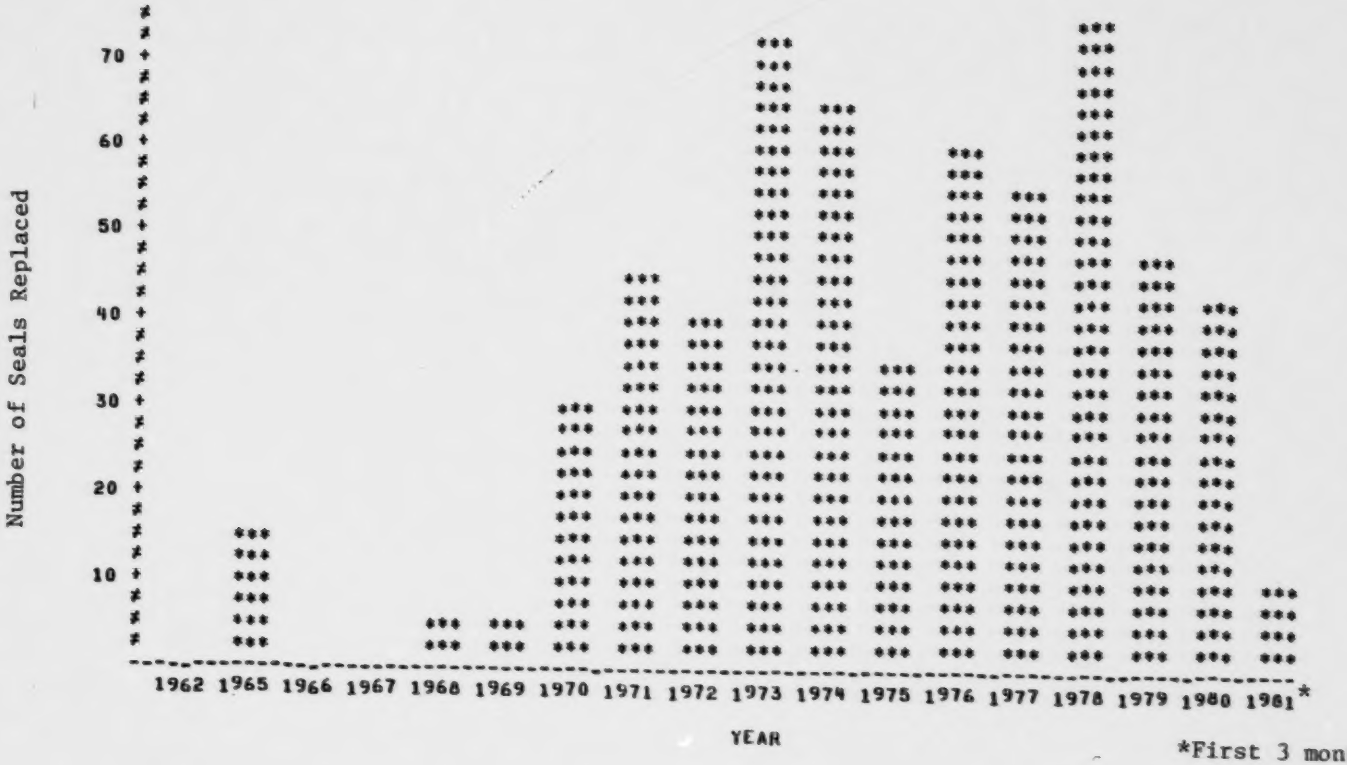
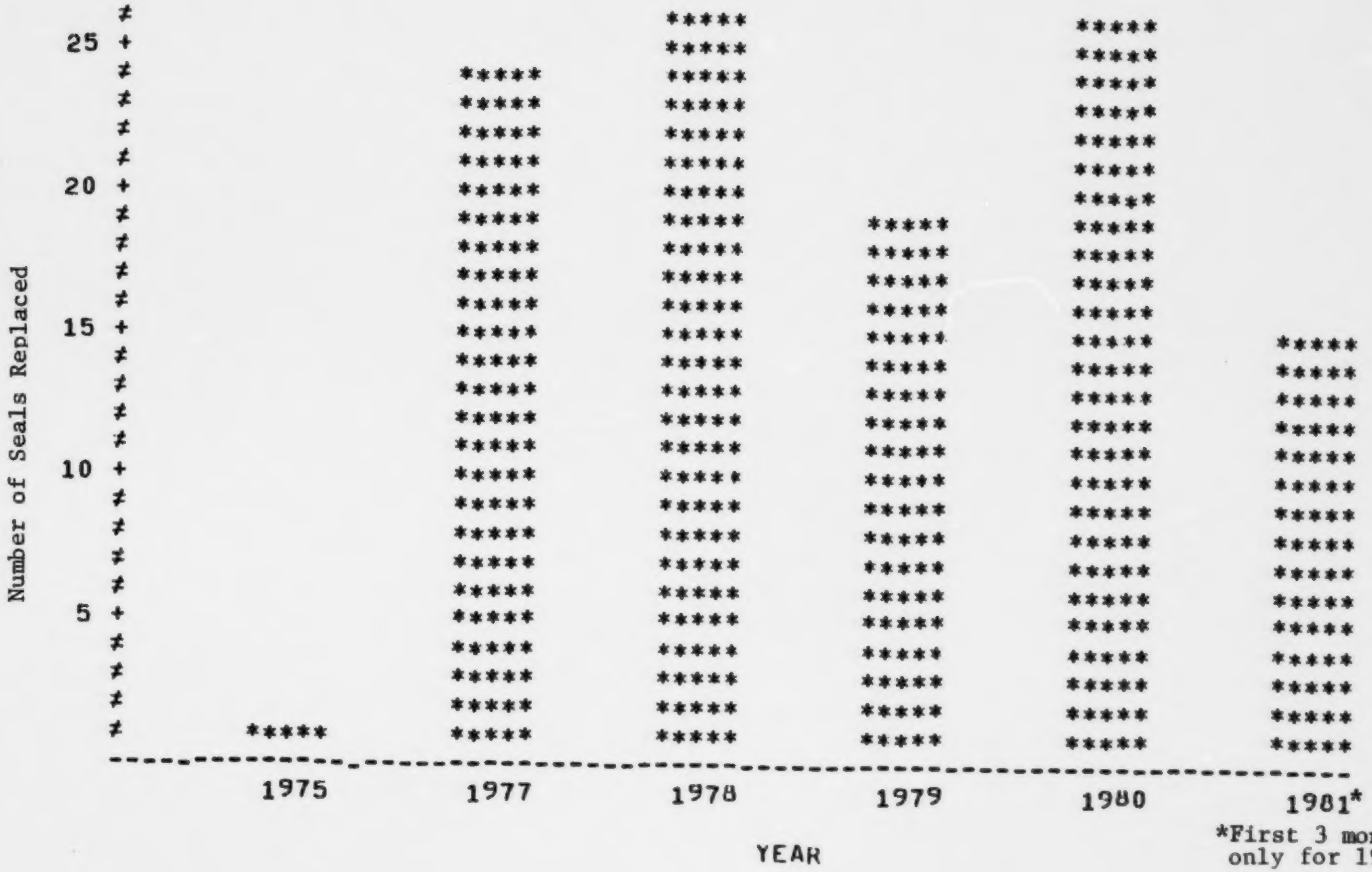


Figure 4-43. Intervals Between Chevron and Powerline Refinery Pump Seal Replacements, (Cumulative Percentage), Last Six Years



*First 3 months
only for 1981

Figure 4-44. Number of Chevron Refinery Pump Seal Replacements by Year



*First 3 months
only for 1981

Figure 4-45. Number of Powerine Refinery Pump Seal Replacements by Year

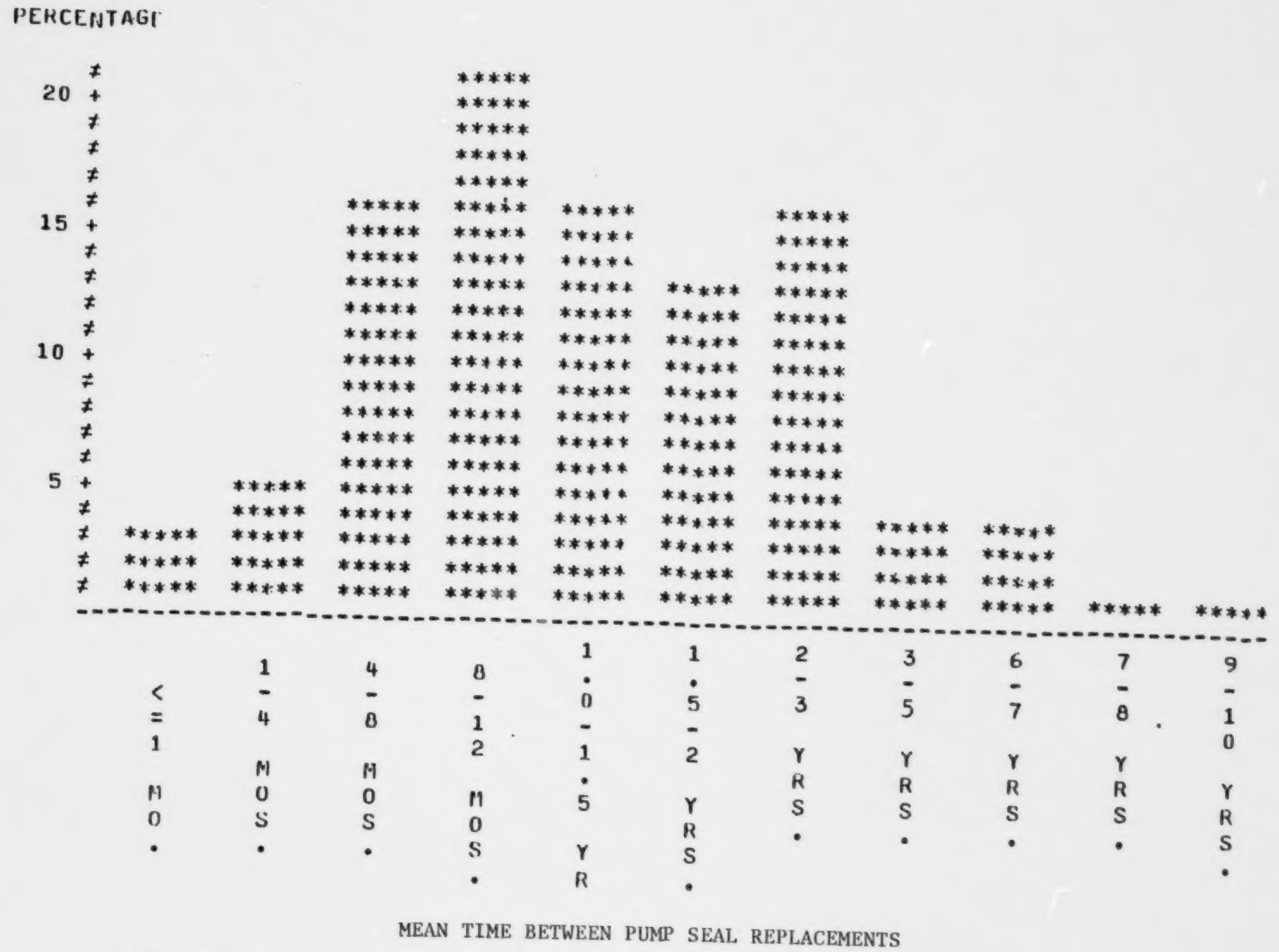


Figure 4-46. Mean Interval Between Seal Replacements for Chevron Refinery Pumps (Percentage), All Years

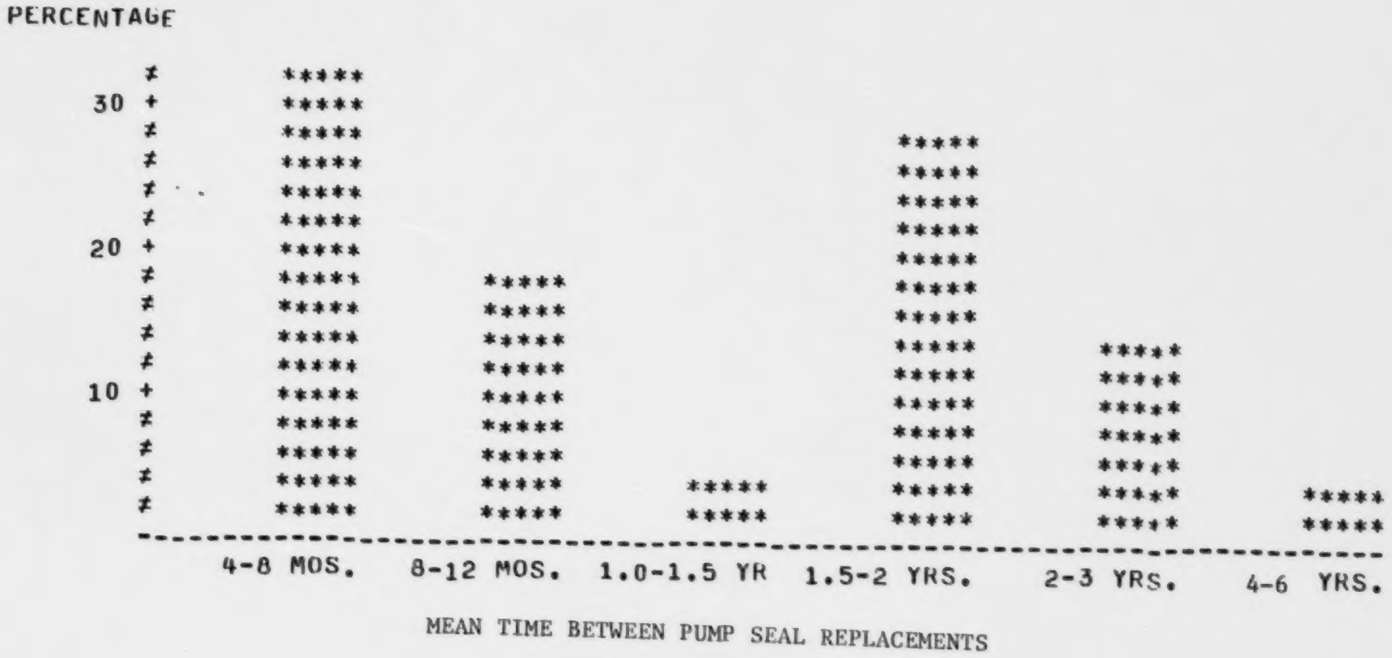


Figure 4-47. Mean Interval Between Seal Replacements for Powerine Refinery Pumps (Percentage), All Years

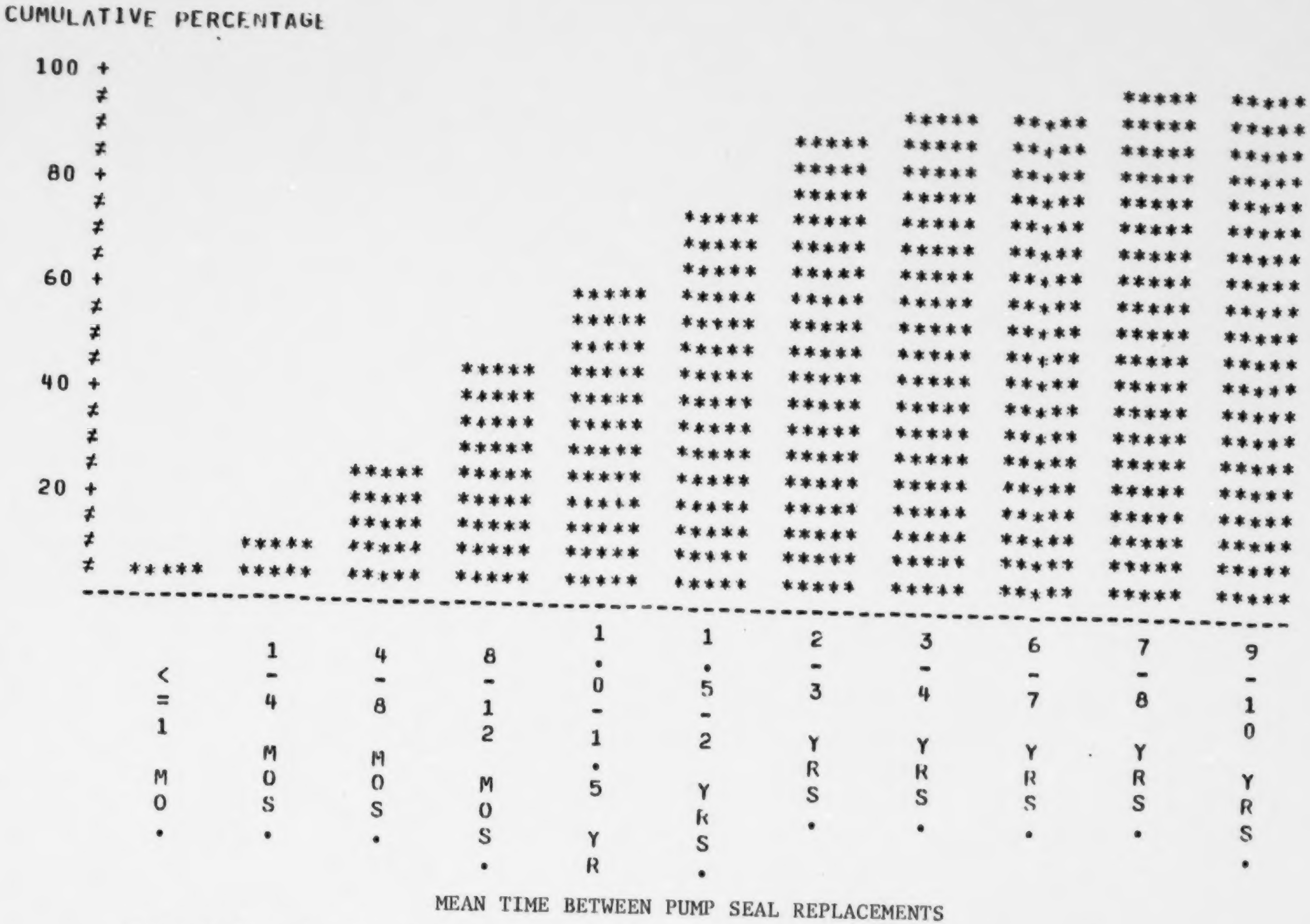


Figure 4-48. Mean Interval Between Seal Replacements for Chevron Refinery Pumps (Cumulative Percentage), All Years

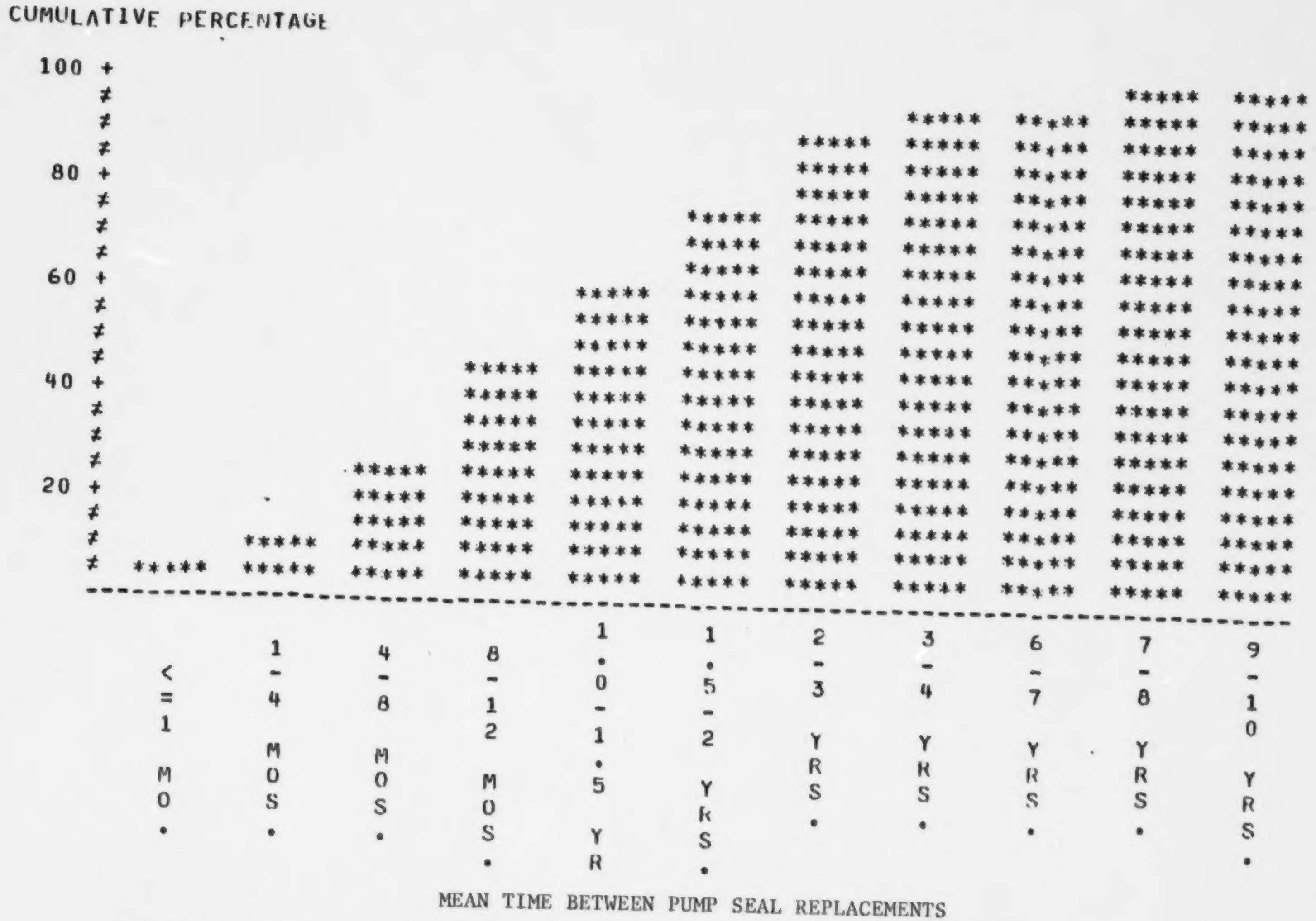


Figure 4-48. Mean Interval Between Seal Replacements for Chevron Refinery Pumps (Cumulative Percentage), All Years

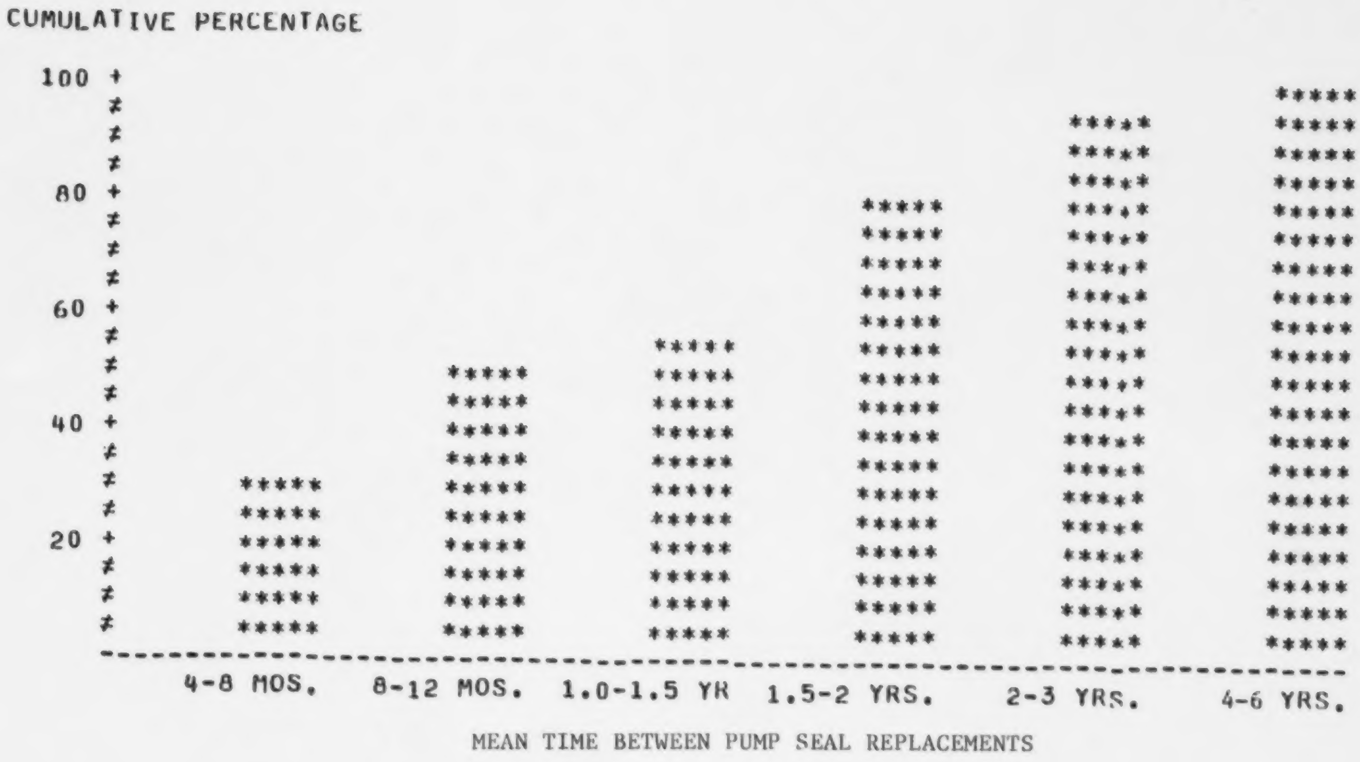


Figure 4-49. Mean Interval Between Seal Replacements for Powerline Refinery Pumps (Cumulative Percentage), All Years

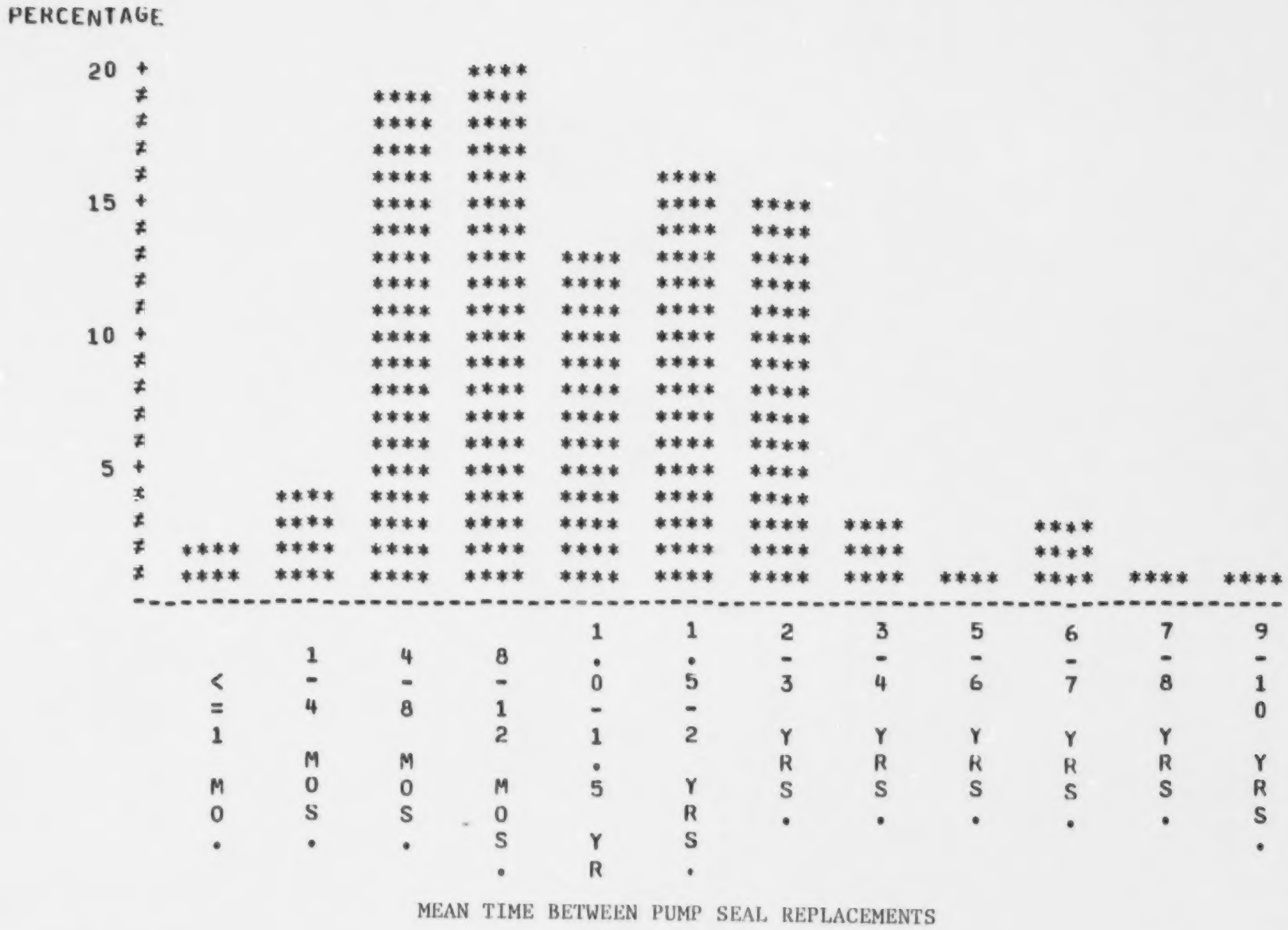


Figure 4-50. Mean Interval Between Seal Replacements for Chevron and Powerine Refinery Pumps (Percentage), All Years

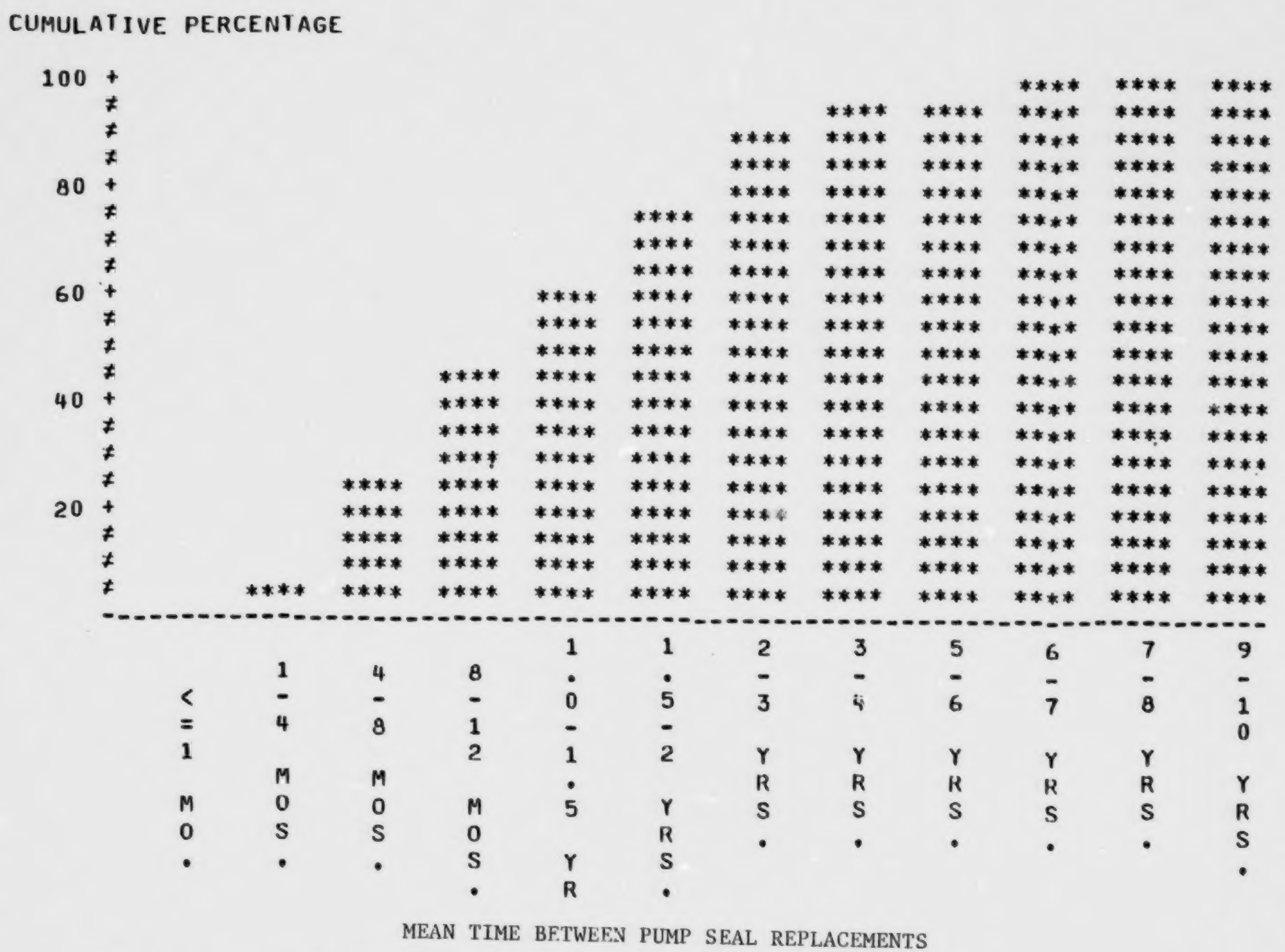


Figure 4-51. Mean Interval Between Seal Replacements for Chevron and Powerine Refinery Pumps (Cummulative Percentage), All Years

The mean pump seal lifetimes represented in the preceeding figures are tabulated for each pump in Table 4-20. Standard deviation, standard error, and number of intervals between seal replacement are also shown for each pump. The number of intervals between seal replacements indicates the number of data points available to estimate the other statistics for each pump.

TABLE 4-20. SUMMARY OF CHEVRON AND POWERINE REFINERY PUMP SEAL REPLACEMENT DATA

PUMP ID	MEAN MONTHS TO SEAL REPLACEMENT	STANDARD DEVIATION	STANDARD ERROR	NUMBER OF INTERVALS BETWEEN SEAL REPLACEMENTS
CPB04	30.6	.	.	1
CPB05	9.6	11.0	5.5	4
CPB06	8.4	9.3	4.1	5
CPB07	15.8	7.8	4.5	3
CPB1A	7.0	4.7	1.8	7
CPB10	35.0	.	.	1
CPB12	19.8	13.7	9.7	2
CPB3A	62.5	.	.	1
CPB8A	24.9	0.2	0.1	2
CP100	4.1	3.6	1.1	10
CP100B	4.9	6.3	2.4	7
CP102B	5.3	5.7	2.3	6
CP103	22.5	.	.	1
CP104	22.4	.	.	1
CP104A	22.5	.	.	1
CP108	22.5	.	.	1
CP109A	22.5	.	.	1
CP112	5.6	5.0	2.5	4
PK501	9.1	13.1	3.7	12
P1	15.5	14.6	5.5	7
P1A	18.1	33.4	10.0	11
P10	9.6	7.4	2.6	8
P100	85.8	45.4	32.1	2
P100A	28.3	31.5	15.7	4
P101A	29.3	.	.	1
P105	5.0	6.7	4.8	2
P14	19.9	22.3	15.7	2
P14A	22.4	24.7	8.7	8
P143	0.6	.	.	1
P143A	22.0	.	.	1
P15	12.0	14.8	5.6	7
P15A	11.8	8.7	5.0	3
P160A	3.4	.	.	1
P161	25.6	4.1	2.9	2
P170	16.2	23.4	8.6	7
P170A	10.4	12.8	4.2	9
P171	3.5	4.8	0.8	33

TABLE 4-20. (Continued)

PUMP ID	MEAN MONTHS TO SEAL REPLACEMENT	STANDARD DEVIATION	STANDARD ERROR	NUMBER OF INTERVALS BETWEEN SEAL REPLACEMENTS
P601	21.3	.	.	1
P603B	5.9	.	.	1
P62	6.1	6.0	1.9	10
P622A	18.4	.	.	1
P623A	81.6	.	.	1
P63	10.3	14.6	3.9	14
P64	6.2	5.3	1.8	8
P720	17.4	11.7	5.2	5
P730	75.7	.	.	1
P736A	10.5	12.6	4.0	10
P750	25.9	10.6	6.1	3
P750A	15.3	6.2	2.3	7
P753A	117.7	.	.	1
P760	13.4	12.3	4.6	7
P760A	5.0	.	.	1
P771	42.5	18.8	13.3	2
P771A	24.9	15.5	7.7	4
P772	11.1	11.6	3.8	9
P8	5.5	.	.	1
P9	25.6	21.5	15.2	2
VP1	6.9	5.3	2.0	7
VP4A	8.9	7.5	3.3	5
VP5	6.6	4.7	1.8	7
3PP2A	9.2	9.4	4.2	5

TABLE 4-20. (Continued)

PUMP ID	MEAN MONTHS TO SEAL REPLACEMENT	STANDARD DEVIATION	STANDARD ERROR	NUMBER OF INTERVALS BETWEEN SEAL REPLACEMENTS
P172	41.7	.	.	1
P180	25.3	33.0	13.4	6
P181	0.4	0.3	0.2	2
P190	5.1	7.4	2.4	9
P191	12.8	12.3	4.6	7
P191A	11.1	11.3	4.2	7
P21	24.9	25.3	11.3	5
P22	11.8	8.7	3.3	7
P220	15.6	9.9	3.5	8
P23	28.4	18.1	9.0	4
P23A	34.7	.	.	1
P25	10.9	16.0	4.1	15
P254	14.7	.	.	1
P26	5.2	4.3	1.0	17
P260	35.0	21.7	9.7	5
P260A	23.6	32.7	12.3	7
P29	8.0	7.6	3.4	5
P3	13.9	10.2	3.6	8
P30	6.0	4.1	2.0	4
P317	11.6	7.6	3.1	6
P36A	31.3	28.8	14.4	4
P39	3.2	5.7	1.2	22
P4	16.9	11.9	5.3	5
P43	8.3	5.3	2.0	7
P43A	2.9	2.3	1.0	5
P43H	7.2	.	.	1
P44	81.5	.	.	1
P45	21.3	27.1	13.5	4
P46A	13.1	15.2	4.2	13
P47	23.3	23.6	9.6	6
P49	9.4	12.7	3.0	17
P5	8.7	2.8	1.6	3
P50	9.3	16.3	3.9	17
P502B	19.2	15.7	9.1	3
P503B	39.3	.	.	1
P6	6.3	8.3	2.6	10
P6A	7.0	8.8	3.1	8

4.6 PROCESS SAMPLING PROCEDURES

Information was recorded by GCA Corporation screening personnel at the Powerine refinery concerning process sampling procedures. This information indicated that approximately one-gallon process samples were obtained at a frequency of three to six times per day. Depending on the type of product sampled, the sample was either routed to sour water treatment facilities or to one of two API separators, servicing sweet or sour charges. No data were gathered on sample pumps.

Depending on the density of the material sampled (i.e., gasoline, lube oil, etc.), the samples could consist of from 6.0 to 7.8 lbs/gallon. If all the sampled material evaporated, this would result in emissions of from 18 lb/day (3 gallons x 6.0 lb/gal) to 47 lbs/day (6 gallons x 7.8 lb/gal). It is expected that most of this material would be recovered through the waste water treatment process.

APPENDIX A

SCAQMD RULE 466

Rule 466. Pumps and Compressors

(Adopted May 7, 1976)
(Amended September 2, 1977)
(Amended December 7, 1979)
(Amended October 3, 1980)

(a) Definitions

(1) For the purpose of this rule:
Volatile Organic Compounds are compounds of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, ammonium carbonate, ethane, methane, 1, 1, 1 trichloroethane, methylene chloride, and trichlorotrifluoroethane, that have a Reid vapor pressure (RVP) greater than 80 mm Hg (1.55 pounds per square inch), or an absolute vapor pressure (AVP) greater than 36 mm Hg (0.7 psi) at 20^0 C.

(2) A Working day is any day of the week except Saturday or Sunday or employee holiday.

(b) Requirements

(1) A person shall not use any pump or compressor handling volatile organic compounds unless such pump or compressor is equipped with adequate seals in good working order or other devices of equal or greater efficiency. Such seals or devices shall be maintained so that there shall not be, during operation or during non-operation:

(A) A leakage of more than three drops per minute.

(B) A visible liquid mist or visible indication of vapor leakage for liquids being pumped which do not condense at ambient conditions.

(C) Any visible indication of leakage at or near the seal/shaft interface for gas compressors.

(2) Any pump or compressor found to leak gaseous volatile organic compounds in excess of 10,000 ppm, measured as hexane, when measured at the potential source with a portable hydrocarbon detection instrument, shall be repaired as follows:

(A) Any pump or compressor having an operable spare permanently connected in the system shall be shut down or the spare pump or compressor placed in service, upon discovery of the leak. Such spare devices shall be inspected with a portable hydrocarbon detection instrument within 48 hours after they have been placed in service. A leaking spare pump or compressor shall be repaired within fifteen working days to a leakage rate of 10,000 ppm or less. If, after repairs are completed, the gaseous leakage rate from the unit in service is greater than 75,000 ppm (10,000 ppm after July 1, 1982) when measured at the source with a portable hydrocarbon detection device, one of the following actions shall be taken:

- (i) Vent the emissions to an air pollution control device, or
- (ii) Petition the Hearing Board for a variance, or
- (iii) Repair or replace the leaking pump or compressor at the next turnaround of the process unit such that the leakage is less than 10,000 ppm. Units to be repaired or replaced at the turnaround shall be tagged to that effect, or otherwise conspicuously marked or coded in a manner easily identifiable to District personnel.

(B) Any pump or compressor having no operable spare permanently connected in the system shall be:

- (i) Repaired within one working day of the discovery of the leak in such a manner that the leakage is minimized: and
- (ii) Repaired or replaced at the next scheduled turnaround of the process unit such that the leakage is less than 10,000 ppm.
- (iii) If, after repairs are completed, the leakage rate is greater than 75,000 ppm. (10,000 ppm after July 1, 1982) then the leak shall be vented to an air pollution control device, or a petition for variance shall be submitted to the Hearing Board.

(c) Inspection Schedule

Persons subject to this rule shall:

- (1) Inspect each operating pump and compressor for any visual leakage once during every 24 hours or operation, except as provided in subsections (c)(2) and (c)(3) of this rule.
- (2) Inspect each operating pump and compressor less than three miles from a continuously manned control center for any visual leakage once during every eight-hour period.
- (3) Inspect each pump used in crude oil production and pipeline transfer for any visible leakage once each week.
- (4) Inspect each pump annually and each compressor quarterly with a portable hydrocarbon detection instrument for gaseous leaks of VOC in excess of 10,000 ppm measured as hexane at the potential source, however, the actual measurement shall be performed per subsection (f)(2).
- (5) Reinspect and repair at the end of six months those pumps of subsection (b)(2)(A) found to be leaking at the annual inspection.

(d) Exemptions

The provisions of this rule shall not apply to any pump or compressor which:

- (1) Has a driver of less than one (1) horsepower or equivalent rated energy or to any pump or compressor operating at temperatures in excess of 260° C (500° F).
- (2) Is vented to an air pollution control system.
- (3) Is shut down for maintenance.

(4) Is regulated by Rule 1005.

(5) Handles liquids or gases with a VOC content of 20 percent or less.

(6) Incorporates dual seals with seal oil barriers, or an equivalent design approved by the Executive Officer, provided that the gases emitted from the seal oil reservoir or vented to the atmosphere are in compliance with the requirements of section (b)(2).

(7) Any reciprocating pump used in crude oil production and pipeline transfer is exempt from the provisions of section (b)(2) of this rule.

(e) Recordkeeping

Each operator of a pump or compressor shall maintain records of inspections required by section (c)(4) in a manner specified by the Executive Officer.

(f) Measurement Requirements

(1) The instruments used for the measurement of gaseous volatile organic compounds shall be equated to calibrating with hexane while sampling at one liter per minute.

(2) Actual measurement of gaseous leakage rates may be conducted within a distance of three inches from the potential source, using a concentration versus distance relationship specified by the Executive Officer.

(g) Effective Dates

The provisions of section (b)(2) shall become effective on July 1, 1981.

Rule 466.1 Valves and Flanges (Adopted November 3, 1978) (Amended June 1, 1979) (Amended May 2, 1980)

(a) Definitions

For the purpose of this rule:

(1) A Valve is defined as any device that regulates the flow of fluid in a piping system by means of an external actuator acting to permit or block passage of fluid including the attached flange and the flange seal.

(2) Commercial Natural Gas is a mixture of gaseous hydrocarbons, chiefly methane, used as a fuel and obtained from a company licensed to dispense such gases.

(3) Background is defined as the ambient concentration of volatile organic compounds determined at least three (3) meters upwind from the valve or flange to be inspected.

(4) Volatile Organic Compounds are compounds of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, ammonium carbonate, ethane, methane, 1,1,1 trichloroethane, methylene chloride and trichlorotrifluoroethane, that have a Reid vapor pressure greater than 80 mm Hg (1.55 pounds per square inch), or an absolute vapor pressure (AVP) greater than 36 mm Hg (0.7 psi) at 20 C.

(5) A Working Day is any day of the week except Saturday or Sunday or employee holiday.

(6) A Refinery is an establishment that processes petroleum as defined in Standard Industrial Classification Manual as Industry No. 2911 Petroleum Refining.

(7) A Flange is defined as a projecting rim on a pipe or piping component used to attach it to another piping detail.

(8) A Leak is defined as:

(A) The dripping of liquid volatile organic compounds at a rate of more than three drops per minute; or

(B) The detection of gaseous volatile organic compounds in excess of 10,000 ppm above background when measured at the source with a portable hydrocarbon detection instrument.

(9) A Chemical Plant is any plant producing organic chemicals and or manufacturing products by organic chemical processes.

(b) Requirements

(1) The operator of a refinery or chemical plant is subject to the provisions of this rule and is responsible for performing the required inspections. Each operator shall, no later than 60 days after the date of adoption of this rule, submit a management plan detailing the component inspection sequence and the schedule for the inspection program to be conducted by the operator at the refinery or chemical plant.

(2) Each valve or flange in a petroleum refinery or chemical plant handling volatile organic compounds shall be inspected in accordance with paragraph (c). Any such valve or flange found to leak shall be repaired in accordance with paragraph (d).

(3) Each valve located at the end of a pipe or line containing volatile organic compounds, shall be sealed with a blind flange, plug or cap when not in use, except:

(A) A valve on a product sampling line;

(B) A safety pressure relief valve;

(C) A bleeder valve in a double block and bleeder valve system.

(4) Each valve which has been discovered to leak in accordance with the definition of paragraph (a)(8) shall be affixed with a record of inspections for the succeeding twelve-month period. Alternative methods of recordkeeping may be used, including the maintenance of records in a centralized location, provided that prior approval of the Executive Officer has been obtained.

(5) Any valve or flange in excess of one valve or flange per day, found to leak by District personnel within five days or after the scheduled inspection of subsection (b)(1) shall constitute a violation of this rule if:

((A) the liquid leakage exceeds three drops per minute, or

(B) the measured volatile organic concentration at the source exceeds 75,000 ppm measured within one centimeter of the source as hexane above background.

(c) Inspection

(1) All valves handling volatile organic compounds shall be inspected for leaks according to the following schedule:

(A) All valves used in any refinery shall be inspected once between January 1, 1979 and June 30, 1979 and once between July 1, 1979 and December 31, 1979.

(B) All valves used in any chemical plant shall be inspected once between July 1, 1979, and December 31, 1979, and once between January 1, 1980, and June 30, 1980.

(C) After January 1, 1980, all valves used in any refinery shall be inspected annually except as provided in subparagraph (c)(1)(E).

(D) After June 30, 1980, all valves used in any chemical plant shall be inspected annually except as provided in subparagraph (c)(1)(E).

(E) **In addition to the annual inspection in subparagraph (c)(1)(C) and (c)(1)(D), each valve found to leak shall be reinspected three months after repair of such leak. Valves found to be leaking at the three months' reinspection shall be** repaired and reinspected after 30 days. Valves found to be leaking after the 30 day reinspection shall be repaired and reinspected at intervals of one-half the prior interval, except no valve need be inspected more frequently than once per day.

(2) Process piping flanges shall be inspected annually.

(3) Continuous monitoring flammable gas detection devices which send a visual or audible signal when a leak occurs, may, with the approval of the Executive Officer, be substituted for periodic inspections using leak detection equipment in applicable facilities or parts of facilities.

(d) Repair
- (1) Each leaking valve or flange shall be repaired within two working days after detection of such leak, except as provided in subparagraph (d)(2).
  The repairs will be such that:
  - (A) There is no dripping of liquid volatile organic compounds at a leakage rate exceeding three drops per minute, or
  - (B) No concentration of gaseous volatile organic compounds in excess of 10,000 ppm above background are detected when measured at the source with a portable hydrocarbon detection instrument.
- (2) If, after repairs are completed, the leak rate greater than three drops per minute or the detectable gaseous volatile organic compound are 10,000 ppm or greater measured at the source, one of the following actions will be taken:
  - (A) Emergency repairs shall be made to reduce the emission rate to the rate stated in (a)(8)(A) and (a)(8)(B);or
  - (B) The emissions from the leak shall be vented into an approved air pollution control device, or
  - (C) A petition for a variance shall be filed on the next working day.
- (3) The persons complying with the provisions of the rule shall be exempt from the provisions of Rule 430 insofar as the provisions of Rule 430 would apply to leaking valves or flanges.

(e) Measurement Requirements
- (1) The instruments used for the measurement of gaseous volatile organic compounds shall be equated to calibrating with hexane and sampling at one liter per minute.
- (2) Actual measurement of gaseous leakage rates may be conducted within a distance of two inches from the potential source using a concentration versus distance relationship specified by the Executive Officer.

(f) Recordkeeping
Persons subject to this rule shall:
- (1) Maintain records of inspections of valves for one year.
  - (A) With the approval of the Executive Officer, inspection records by operational system or plant area will be adequate to demonstrate compliance with annual inspection requirements.
  - (B) Annual inspection records for the continuous monitoring equipment described in subparagraph (c)(3) shall not be required, provided that records are maintained for out-of-tolerance conditions as indicated by the monitoring equipment.
- (2) Make inspection records available for review to the Executive Officer upon request.
- (3) Recordkeeping requirements shall not apply to the routine periodic inspection of flanges.

(g) Exemptions
- (1) The provisions of this rule shall not apply to:
  - (A) Valves or flanges handling gases in which commercial natural gas is the only volatile organic compound.

(B) All valves or flanges which are located in areas which make inspection infeasible or unsafe for personnel provided that prior concurrence of the Executive Officer has been obtained.

(C) Valves or flanges handling gases with a hydrogen composition of 80 percent or greater.

(D) Valves or flanges regulated by Rule 1005.

(h) Effective Dates

(1) The owner or operator of any refinery shall comply with the requirements of paragraph (b)(3) no later than January 3, 1979.

(2) The owner or operator of any chemical plant shall comply with the requirements of paragraph (b)(3) no later than July 4, 1979.

(3) The owner or operator of any chemical plant or refinery shall comply with the requirements of this rule 60 days from the date of adoption.

Rule 467. Safety Relief Valves

A person shall not use any safety pressure relief valve on any equipment handling organic materials above 776 mm Hg (15 pounds per square inch) absolute pressure unless the safety pressure relief valve is vented to a vapor recovery or disposal system, protected by a ruptured disc, or is maintained by an inspection system approved by the Air Pollution Control Officer.

The provisions of this rule shall not apply to any safety pressure relief valve of 2.5 centimeters (1 inch) pipe size or less.

APPENDIX B

METHOD 21. DETERMINATION OF VOLATILE ORGANIC COMPOUND LEAKS (JANUARY, 1981)

1. Applicability and Principle

1.1 Applicability. This method applies to the determination of volatile organic compound (VOC) leaks from organic process equipment. These sources include, but are not limited to, valves, flanges and other connections, pumps and compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, and access door seals.

1.2 Principle. A portable instrument is used to detect VOC leaks from individual sources. The instrument detector is not specified, but it must meet the specifications and performance criteria contained in paragraph 2.1.

2. Apparatus

2.1 Monitoring Instrument. The monitoring instrument shall be as follows:

2.1.1 Specifications.

a. The VOC instrument detector shall respond to the organic compounds being processed. Detectors which may meet this requirement include, but are not limited to, catalytic oxidation, flame ionization, infrared absorption, and photoionization.

b. The instrument shall be intrinsically safe for operation in explosive atmospheres as defined by the applicable U.S.A. Standards (e.g., National Electrical Code by the National Fire Prevention Association).

c. The instrument shall be able to measure the leak definition concentration specified in the regulation.

d. The instrument shall be equipped with a pump so that a continuous sample is provided to the detector. The nominal sample flow rate shall be 1-3 liters per minute.

e. The scale of the instrument meter shall be readable to ±5 percent of the specified leak definition concentration.

2.1.2 Performance Criteria. The instrument must meet the following performance criteria. The definitions and evaluation procedures for each parameter are given in Section 4.

2.1.2.1 Response Time. The instrument response time must be 30 seconds or less. The response time must be determined for the instrument system configuration to be used during testing, including dilution equipment. The use of a system with a shorter response time than that specified will reduce the time required for field component surveys.

2.1.2.2 Calibration Precision. The calibration precision must be less than or equal to 10 percent of the calibration gas value.

2.1.2.3 Quality Assurance. The instrument shall be subjected to the response time and calibration precision tests prior to being placed in service. The calibration precision test shall be repeated every 6 months thereafter. If any modification or replacement of the instrument detector is required, the instrument shall be retested and a new 6-month quality assurance test schedule will apply. The response time test shall be repeated if any modifications to the sample pumping system or flow configuration is made that would change the response time.

2.3 Calibration Gases. The monitoring instrument is calibrated in terms of parts per million by volume (ppmv) of the compound specified in the applicable regulation. The calibration gases required for monitoring and instrument performance evaluation are a zero gas (air, <3 ppmv VOC) and a calibration gas in air mixture approximately equal to the leak definition specified in the regulation. If cylinder calibration gas mixtures are used, they must be analyzed and certified by the manufacturer to be within ±2 percent accuracy. Calibration gases may be prepared by the user according to any accepted gaseous standards preparation procedure that will yield a mixture accurate to within ±2 percent. Alternative calibration gas species may be used in place of the calibration compound if a relative response factor for each instrument is determined so that calibrations with the alternative species may be expressed as calibration compound equivalents on the meter readout.

3. Procedures

3.1 Calibration. Assemble and start up the VOC analyzer and recorder according to the manufacturer's instructions. After the appropriate warm-up period and zero or internal calibration procedure, introduce the calibration gas into the instrument sample probe. Adjust the instrument meter readout to correspond to the calibration gas value. If a dilution apparatus is used, calibration must include the instrument and dilution apparatus assembly. The nominal dilution factor may be used to establish a scale factor for converting to an undiluted basis. For example if a nominal 10:1 dilution apparatus is used, the meter reading for a 10,000 ppm calibration compound would be set at 1000. During field surveys, the scale factor of 10 would be used to convert measurements to an undiluted basis.

3.2 Individual Source Surveys.

3.2.1 Case I - Leak Definition Based on Concentration Value. Place the probe inlet at the surface of the component interface where leakage could occur. Move the probe along the interface periphery while observing the instrument readout. If an increased meter reading is observed, slowly probe the interface where leakage is indicated until the maximum meter reading is obtained. Leave the probe inlet at this maximum reading location for approximately two times the instrument response time. If the maximum observed meter reading is greater than the leak definition in the applicable regulation, record and report the results as specified in the regulation reporting requirements. Examples of the application of this general technique to specific equipment types are:

a. Valves--The most common source of leaks from valves is at the seal between the stem and housing. Place the probe at the interface where the stem exits the packing gland and sample the stem circumference. Also, place the probe at the interface of the packing gland take-up flange seat and sample the periphery. In addition, survey valve housings of multipart assembly at the surface of all interfaces where leaks can occur.

b. Flanges and Other Connections--For welded flanges, place the probe at the outer edge of the flange-gasket interface and sample around the circumference of the flange. Sample other types of nonpermanent joints (such as threaded connections) with a similar traverse.

c. Pumps and Compressors--Conduct a circumferential traverse at the outer surface of the pump or compressor shaft and seal interface. If the source is a rotating shaft, position the probe inlet within one centimeter of the shaft seal interface for the survey. If the housing configuration prevents a complete traverse of the shaft periphery, sample all accessible portions. Sample all other joints on the pump or compressor housing where leakage can occur.

d. Pressure Relief Devices--The configuration of most pressure relief devices prevents sampling at the sealing seat interface. For those devices equipped with an enclosed extension, or horn, place the probe inlet at approximately the center of the exhaust area to the atmosphere for sampling.

e. Process Drains--For open drains, place the probe inlet at approximately the center of the area open to the atmosphere for sampling. For covered drains, place the probe at the surface of the cover interface and conduct a peripheral traverse.

f. Open-Ended Lines or Valves--Place the probe inlet at approximately the center of the opening to the atmosphere for sampling.

g. Seal System Degassing Vents and Accumulator Vents--Place the probe inlet at approximately the center of the opening to the atmosphere for sampling.

h. Access Door Seals--Place the probe inlet at the surface of the door seal interface and conduct a peripheral traverse.

3.2.2 Case II-Leak Definition Based on "No Detectable Emission".

a. Determine the local ambient concentration around the source by moving the probe inlet randomly upwind and downwind at distance of one to two meters from the source. If an interference exists with this determination due to a nearby emission or leak, the local ambient concentration may be determined at distances closer to the source, but in no case shall the distance be less than 25 centimeters. Note the ambient concentration and then move the probe inlet to the surface of the source and conduct a survey as described in 3.2.1. If a concentration increase greater than 2 percent of the concentration-based leak definition is obtained, record and report the results as specified by the regulation.

b. For those cases where the regulation requires a specific device installation, or that specified vents be ducted or piped to a control device, the existence of these conditions shall be visually confirmed. When the regulation also requires that no detectable emissions exist, visual observations and sampling surveys are required. Examples of this technique are:

i. Pump or Compressor Seals--If applicable, determine the type of shaft seal. Perform a survey of the local area ambient VOC concentration and determine if detectable emissions exist as described in 3.2.2.a.

ii. Seal System Degassing Vents, Accumulator Vessel Vents, Pressure Relief Devices--If applicable, observe whether or not the applicable ducting or piping exists. Also, determine if any sources exist in the ducting or piping where emissions could occur prior to the control device. If the required ducting or piping exists and there are no sources where the emissions could be vented to the atmosphere prior to the control device, then it is presumed that no detectable emissions are present.

4. Instrument Performance Evaluation Procedures

4.1 Definitions.

4.1.1 Calibration Precision. The difference between the average VOC concentration indicated by the meter readout for consecutive calibration repetitions and the known concentration of a test gas mixture.

4.1.2 Response Time. The time interval from a step change in VOC concentration at the input of the sampling system to the time at which 90 percent of the corresponding final value is reached as displayed on the instrument readout meter.

4.2 Evaluation Procedures. At the beginning of the instrument performance evaluation test, assemble and start up the instrument according to the manufacturer's instructions for recommended warmup period and preliminary adjustments. If a dilution apparatus is used during field surveys, the evaluation procedure must be performed on the instrument-dilution system combination.

4.2.1 Calibration Precision Test. Make a total of nine measurements by alternately using zero gas and the specified calibration gas. Record the meter readings (example data sheet shown in Figure 21-1).

4.2.2 Response Time Test Procedure. Introduce zero gas into the instrument sample probe. When the meter reading has estabilized, switch quickly to the specified calibration gas. Measure the time from concentration switching to 90 percent of final stable reading. Perform this test sequence three times and record the results (example data sheet given in Figure 21-2).

4.3 Calculations. All results are expressed as mean values, calculated by:

$$\overline{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

where:

x_i = Value of the individual measurements.

Σ = Sum of the individual values.

$\overline{x}$ = Mean value.

n = Number of measurements.

Instrument ID ____________________

Calibration Gas Data

Calibration = ______ ppmv

Run No.	Instrument Meter Reading, ppm	Difference(1) ppm
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		

Mean Difference ______

$$\text{Calibration Precision} = \frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}} \times 100 \quad \_\_\_\_\_\_$$

---

(1) Calibration Gas Concentration - Instrument Reading

Figure B-1. Calibration Precision Determination

Instrument ID ______________________________

Calibration Gas Concentration ________________

90% Response Time:

1. _______ Seconds
2. _______ Seconds
3. _______ Seconds

Mean Response Time ________ Seconds

Figure B-2. Response Time Determination

APPENDIX C
TEST METHODS

General screening survey procedures, detailed source screening procedures, and hydrocarbon detector calibration procedures are presented in this appendix.

C.1 SCREENING SURVEY PROCEDURES

The first step in the screening survey was to precisely define the process unit boundaries. For the purposes of this study, a process unit was defined as a set of process equipment which operated independently and included all sections necessary to achieve its process objective. A plot plan of the unit was then obtained and marked with the appropriate boundaries. A brief description of the process unit definitions were recorded in the contractor's QC/QA record book.

The next step was to obtain a simplified flow diagram of the process and note the major streams. The actual screening and data collection were done by following each stream. This minimized the time required to determine repetitive data (such as the major organic components). For instance, logical starting points were where feed lines entered the process boundary. The screening team followed these lines screening all sources until they terminated at a reactor or separation step. Minor loops (like a bypass around a control valve, pump, or heat exchanger) were screened on the initial pass. Larger loops of process equipment (such as parallel passes and processing alternatives) were treated as separate streams.

Each source was uniquely marked to indicate that it had been screened. Once all the equipment along the major streams had been screened, the unit was divided into a grid to search for fittings missed on the initial survey. Close cooperation with the company escort helped avoid non-VOC sources (such as steam or cooling water lines). Only those sources containing at least 10 weight percent VOC were screened.

If any sources were physically inaccessible or unsafe to approach, they were identified by code number and the reasons for omitting them were documented. This provided important information on the percentage of such sources for incorporation in regulatory monitoring plans.

The unit survey was complete when all sources in the unit had been dealt with by screening, identification as a non-VOC fitting, or identification as a source not screened (with a comment code recorded for not screened). The raw data sheets were then copied. The originals were sent to Radian for data processing. One copy was retained by the contractor, and one copy was given to the plant management.

C.2 SOURCE SCREENING PROCEDURES

The term "screening" refers to measurement of the hydrocarbon concentration close to the point of potential leakage, such as at the valve stem, pump seal, etc. This concentration was measured with a portable, explosion-proof hydrocarbon detector. The instrument used on this program was the Century Systems OVA-108, certified to be intrinsically safe by Factory Mutual. The OVA-108 has a log-scale readout with a range of 1 to 10,000 ppmv and can be equipped with a dilution probe to extend the range by a factor of ten.

For source screening, the detector probe tip was placed as close as possible to the point of suspected leakage. A slow traverse of the circumference of the leaking area was made, and the maximum reading on the instrument was noted. That maximum reading was the "screening value" for the source. For some sources, the reading fluctuated considerably. In such cases, the screening value was the maximum repeatable reading. If a high background concentration was noted and was less than 50 percent of the screening value, only the net contribution of the source was recorded. If the background was greater than 50 percent of the screening value, this was notedin the comment code field and no screening value was recorded. In all cases, no attempt was made to shiled the source from wind action.

If the initial traverse revealed that the maximum screening value was greater than 10,000 ppmv (full-scale deflection), the dilution probe was attached and the point of maximum leakage was located. When the dilution probe was used, the meter reading was multiplied by the dilution factor (10), and this value was recorded. If the initial traverse indicated a value greater than 10,000 ppmv, but with the dilution probe it was less than 10,000 ppmv (1000 x 10), a value of 10,001 ppmv was recorded as the screening value.

A probe extension can be attached to the OVA-108 readout assembly. This probe extension was used for screening sources that were not within reach by using the standard probe. If a source could not be screened, the appropriate comment code was entered on the data sheet.

Care was taken to avoid fouling of the probe with grease, dust, or liquids. A short piece of Teflon tubing was used as a probe tip extender and snipped off as the tip fouled. If a surface to be screened was obviously dirty, the probe tip was held just over the surface to avoid scooping up contaminants. Some fouling was unavoidable, so the probe tip sintered steel filter was cleaned at least daily, and the side-pack filter was cleaned weekly.

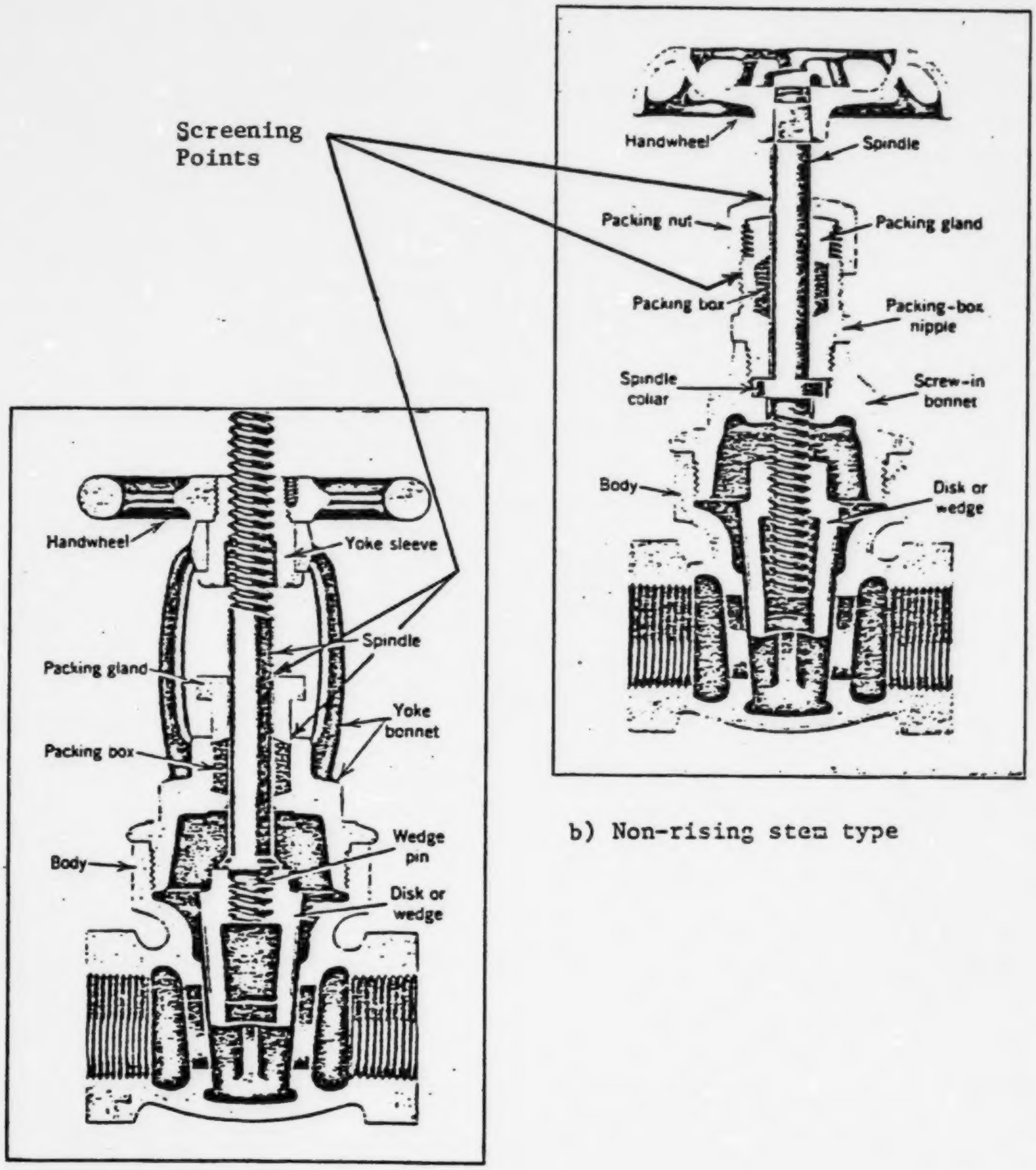
After the morning warm-up and calibration, the following materials were assembled:

- the OVA-108 and dilution probe,
- a clipboard with a transparent plastic cover,
- a supply of fresh data sheets,
- a list of coding protocol,
- writing instruments,
- colored plastic marking tape or marking crayons,
- pipe cleaners,
- rags or paper towels, and
- tool belts, fanny-packs, etc., as necessary to efficiently organize the equipment.

With these preparations accomplished, the screening survey was begun. The following sections provide screening procedures for various sources, as a supplement to the general information in Method 21.

C.2.1 SCREENING VALVES

This section gives guidelines that were used to recognize and screen various types of valves. One of the most common valves encountered was the gate valve, two types of which are shown in Figure C-1. The normal screening points were at the stem and the packing gland, as shown in the illustration. The gate valve is commonly used in block valve service because


Screening Points
Handwheel
Spindle
Packing nut
Packing gland
Packing box
Packing-box nipple
Spindle collar
Screw-in bonnet
Body
Disk or wedge
Handwheel
Yoke sleeve
Spindle
Packing gland
Yoke bonnet
Packing box
Body
Wedge pin
Disk or wedge

b) Non-rising stem type

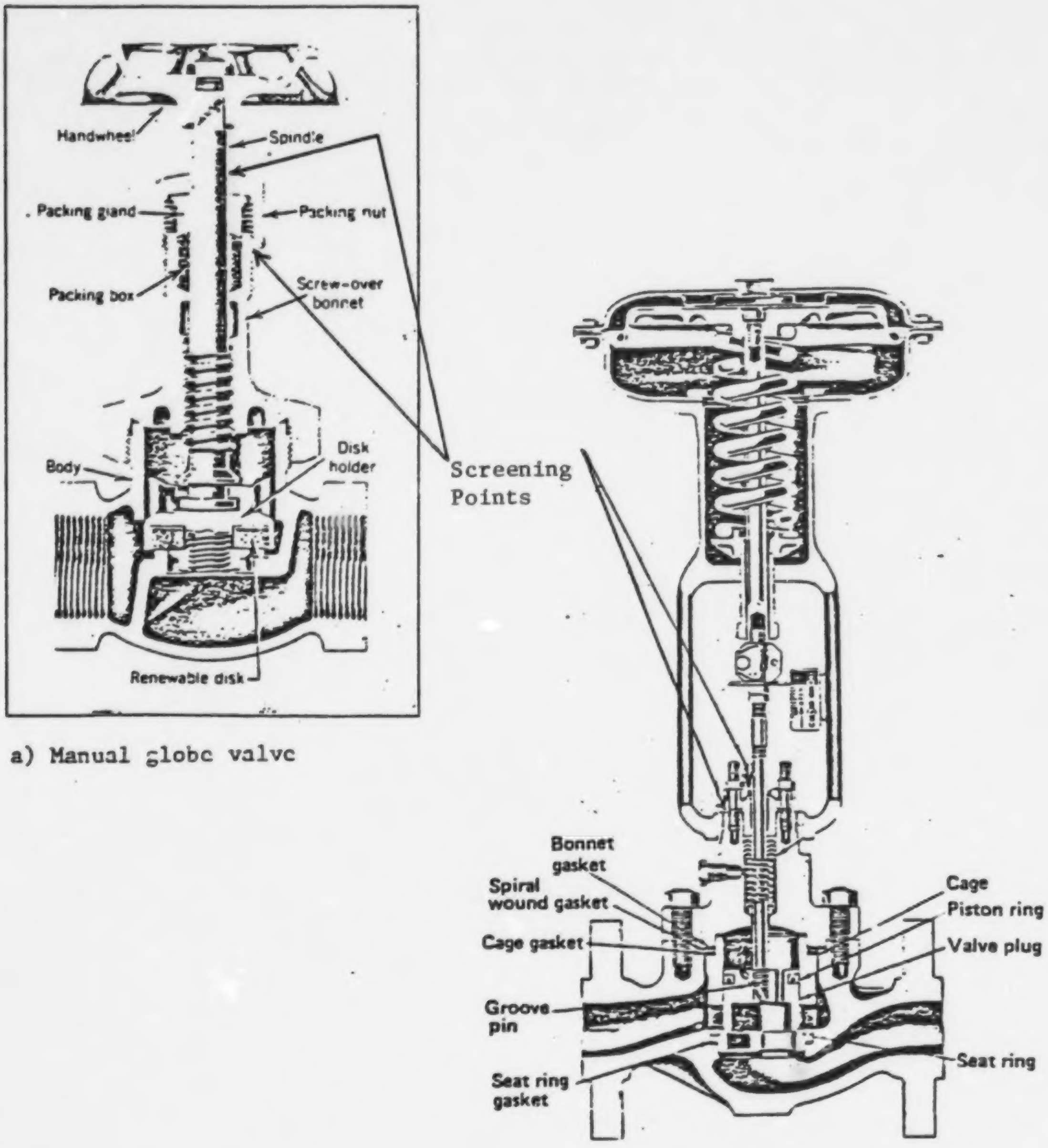
a) Rising stem type

Figure C-1. Gate valves.

it combines a good positive seal when closed and low pressure drop when fully open. It is hard to distinguish between a gate valve and a globe valve from the exterior. If the company escort could not supply this information, it was assumed that all similar valves in block service were gate valves, while all such valves in throttling service (control valves, manual valves in a bypass around a control valve, etc.) were globe valves. Two types of globe valves are shown in Figure C-2.

Plug valves and ball valves were easily differentiated from gate and globe valves by the fact that they go from full open to closed in 90° of stem rotation. The actuator is usually a bar handle instead of a wheel. Two plug valves are shown in Figure C-3, and a ball valve is shown in Figure C-4. Plug valves are normally lubricated while ball valves are not, and the body shapes are also slightly different. Screening points are indicated on the drawings.

Figure C-5 shows a butterfly valve. This type of valve was easily distinguished by its thin body which appears to be a short section of pipe between two flanges. There are several different types of actuators for butterfly valves, only one of which is pictured. Butterfly valves are used for throttling flow, since they do not provide a positive shutoff. These valves were screened at the point where the stem emerges from the body, which is blocked from view on the drawing. These valves often have a seal on both sides of the pipe. Both seals were screened, but this valve was considered to be one source, and only the maximum screening value was recorded.


Handwheel
Spindle
Packing gland
Packing nut
Packing box
Screw-over bonnet
Body
Disk holder
Renewable disk
Screening Points
Bonnet gasket
Spiral wound gasket
Cage gasket
Groove pin
Seat ring gasket
Cage
Piston ring
Valve plug
Seat ring

a) Manual globe valve

b) Globe type control valve

Figure C-2. Globe valves.

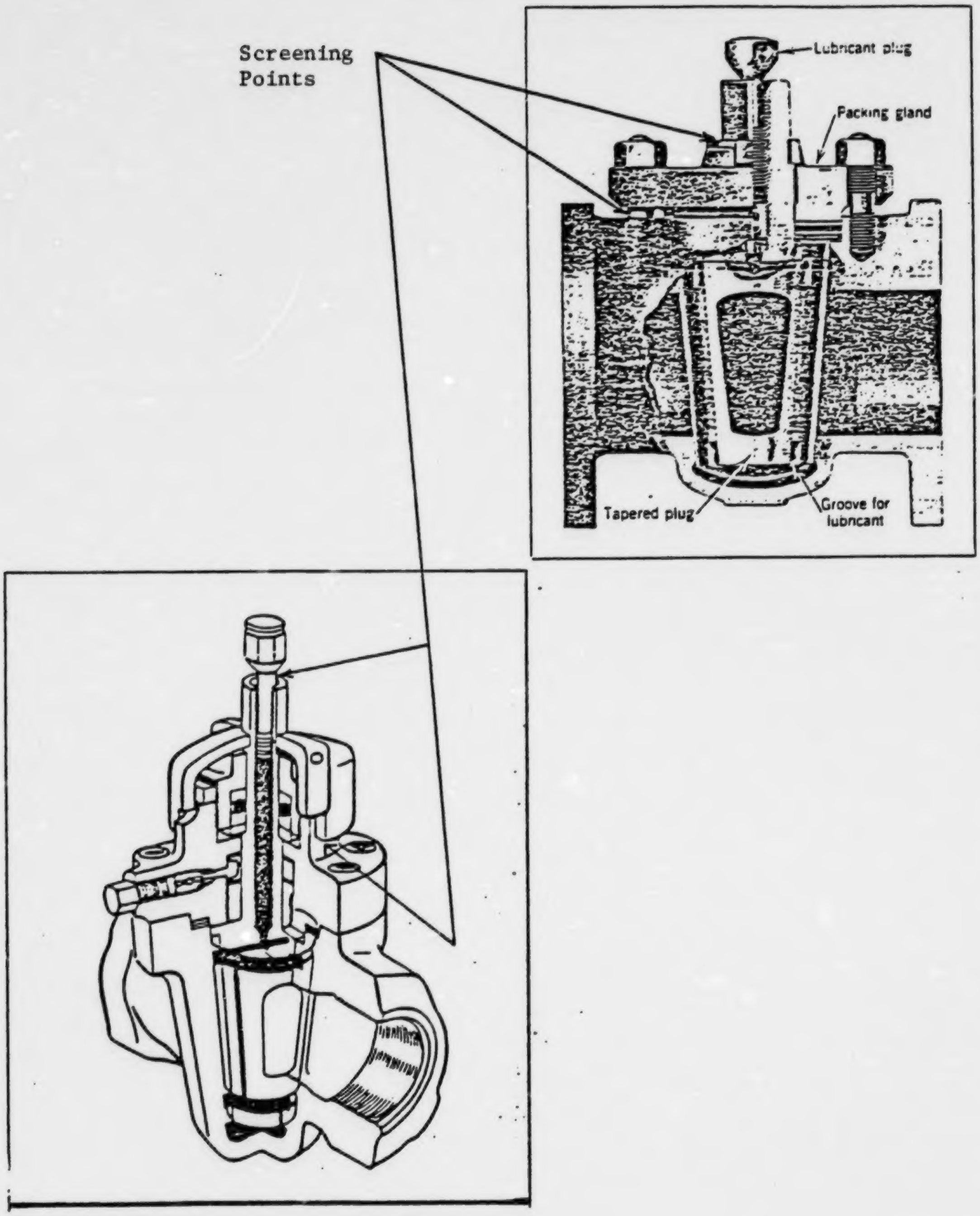

Screening Points
Lubricant plug
Packing gland
Tapered plug
Groove for lubricant

Figure C-3. Lubricated plug valves.

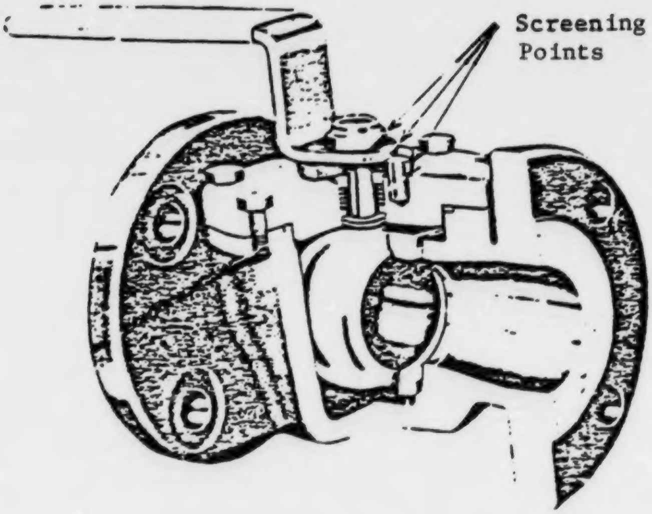

Screening
Points

Figure C-4. Ball valve.

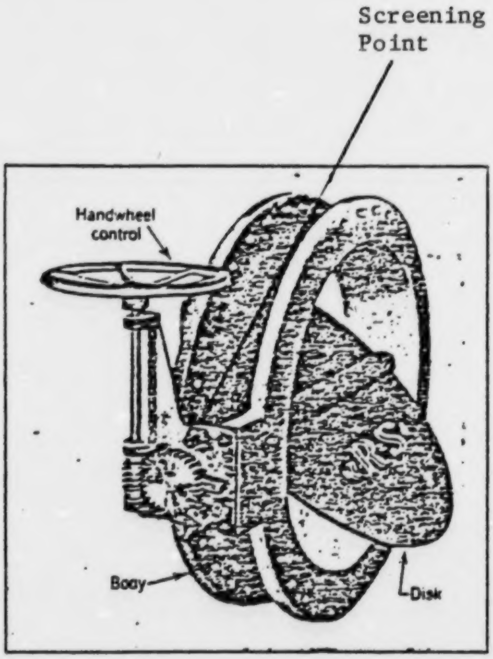

Screening
Point
Handwheel
control
Body
Disk

Figure C-5. Butterfly valve.

C.2.2 SCREENING PUMPS, COMPRESSORS, AND AGITATORS

Most pumps, compressors, and agitators were screened at the shaft seal. This point is indicated for two common pump types in Figures C-6 and C-7. Care was taken when using a metallic probe tip so as not to contact the rotating shaft, since this could have caused a spark. This also helped minimize fouling of the probe tip and filter. Care was taken to prevent any liquids from being drawn into the probe.

There are many possible configurations of the seal area on pumps and compressors. Sometimes an extensive guard is used with only small cut-outs for ventilation. If these cut-outs allowed safe access to only a portion of a shaft seal, only that portion was screened. Guards or splash covers were not removed unless explicit permission was given by the company escort. Some seal areas are totally enclosed and vented to the atmosphere or some control device. In these cases, the screening teams had instructions to screen the vent exit if it was accessible. No screening was necessary if it vented to a control device. Compressors and double seal pumps sometimes use a seal oil system, and the proper screening point for these was the center of the vent from the seal oil reservoir.

It was quite difficult to distinguish different types of seals from the exterior. If the application used a reciprocating shaft, it was assumed that it used a packed seal. The company escort provided the seal type. Figures C-8 through C-12 show cut-away views of the most important seal types.

C.2.3 SCREENING DRAINS, RELIEF VALVES, AND OPEN-ENDED LINES

Fugitive leaks from most other sources (open-ended lines, drains, and relief valves) are emitted through a regularly shaped opening. If that

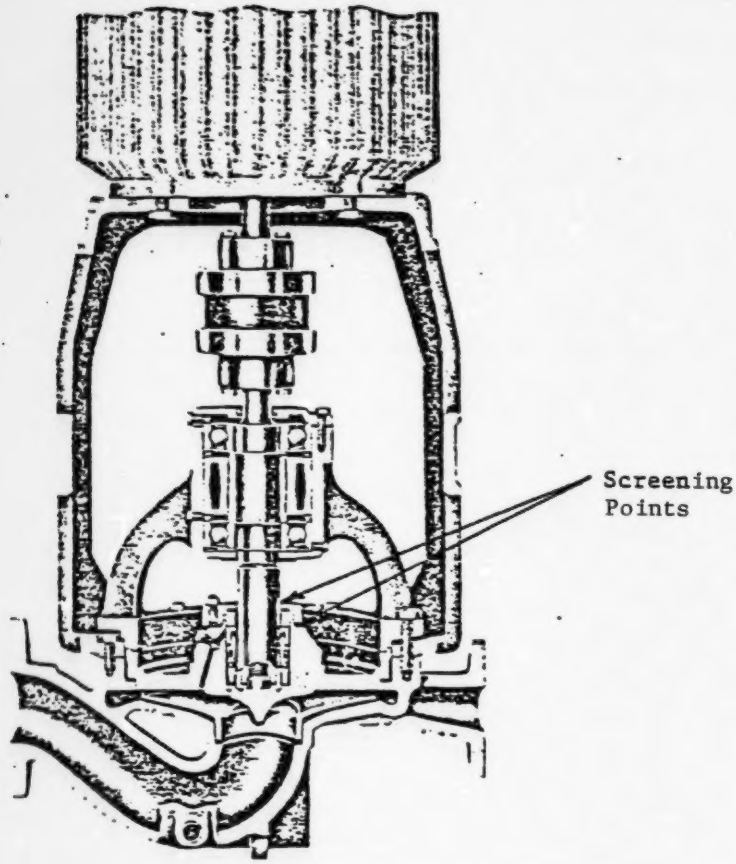

Screening
Points

Figure C-6. Vertical centrifugal pump.

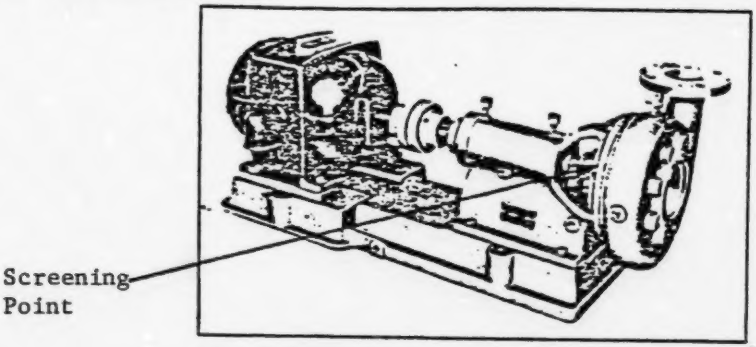

Screening
Point

Figure C-7. Horizontal centrifugal pump.

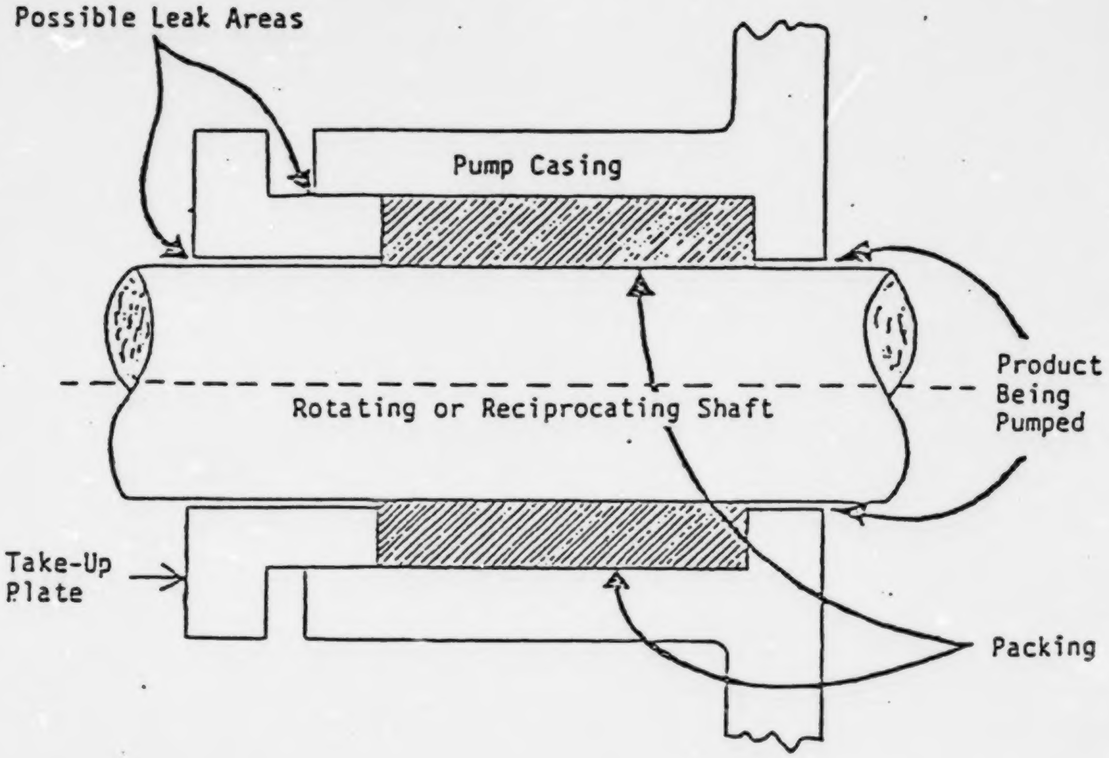

Possible Leak Areas
Pump Casing
Rotating or Reciprocating Shaft
Product
Being
Pumped
Take-Up
Plate
Packing

Figure C-8. Diagram of a simple packed seal.

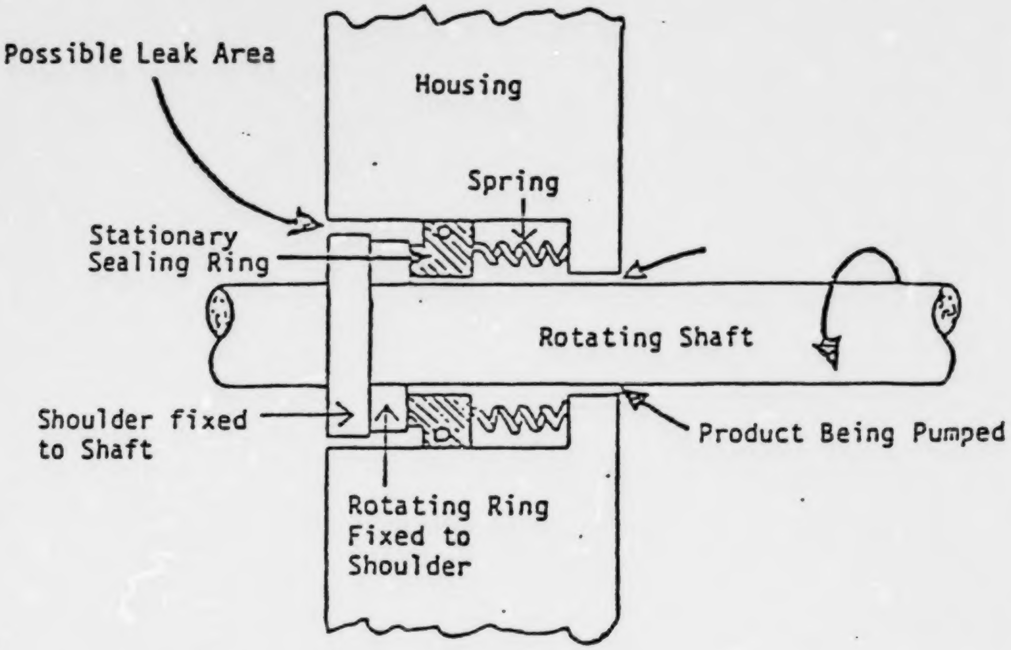
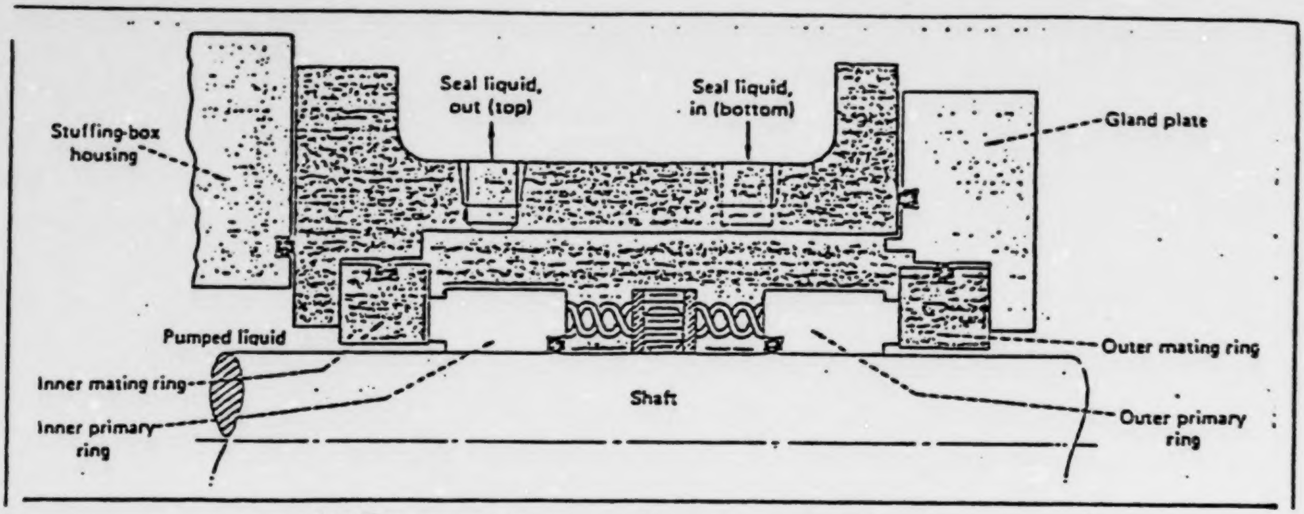
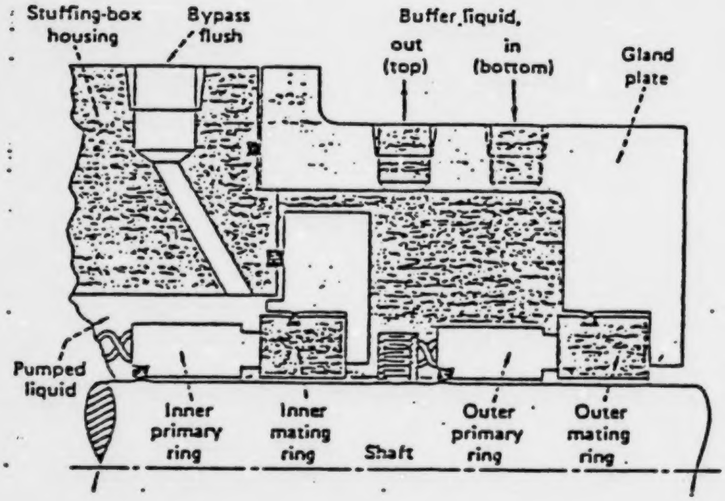

Possible Leak Area
Housing
Spring
Stationary Sealing Ring
Rotating Shaft
Shoulder fixed to Shaft
Product Being Pumped
Rotating Ring Fixed to Shoulder

Figure C-9. Diagram of a simple mechanical seal.


Seal liquid, out (top)
Seal liquid, in (bottom)
Stuffing-box housing
Gland plate
Pumped liquid
Outer mating ring
Inner mating ring
Shaft
Inner primary ring
Outer primary ring

TYPICAL DOUBLE MECHANICAL SEAL


Stuffing-box housing
Bypass flush
Buffer liquid,
out (top)
in (bottom)
Gland plate
Pumped liquid
Inner primary ring
Inner mating ring
Shaft
Outer primary ring
Outer mating ring

TANDEM MECHANICAL SEALS

Figure C-10. Double mechanical seals for pumps.

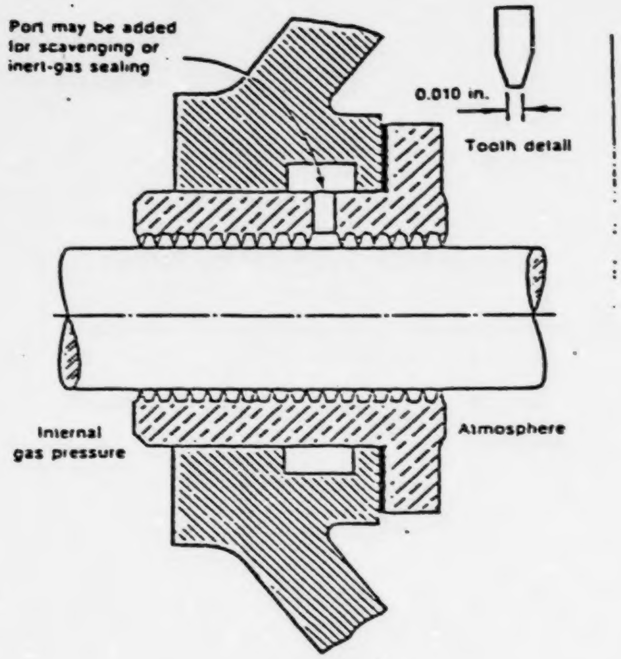
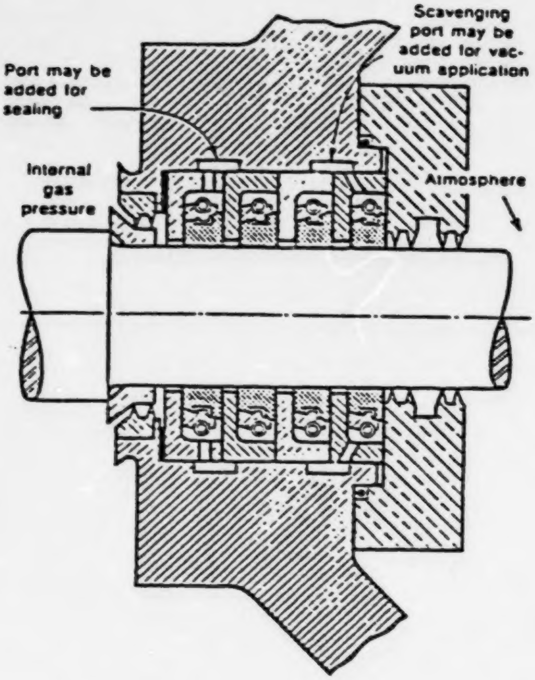

Port may be added for scavenging or inert-gas sealing
0.010 in.
Tooth detail
Internal gas pressure
Atmosphere

Figure C-11. Honeycomb labyrinth compressor seal.


Port may be added for sealing
Scavenging port may be added for vacuum application
Internal gas pressure
Atmosphere

RESTRICTIVE CARBON RING SEALS

Figure C-12. Mechanical seals for compressors.

opening was very small (as in sampling lines of less than one-inch diameter), a single reading in the center was sufficient. For larger openings (like a six-inch diameter drain or a relief valve horn), it was necessary to monitor concentrations at the perimeter of the opening as well as at the center. For even larger sources (like a wash-up drain grate), a grid of readings was taken on about six-inch centers. The centroid of the opening of the downstream valve was the screening point for open-ended lines sealed with a second valve. For all these techniques, it was always the single maximum value that was recorded. A cut-away drawing of a relief valve is shown in Figure C-13.

C.2.4 SCREENING PUMPS AND COMPRESSORS AT VARIOUS DISTANCES

Each pump or compressor seal with a screening value greater than or equal to 1000 ppmv was also screened by placing the detector probe at various distances from the leak source. If shaft guards prevented screening within 1 cm. of the source or if screening was at a closed vent or seal oil reservoir vent, the additional screening was not performed.

Additional screenings were performed at 1 cm., 2.5 cm., 5 cm., 10 cm., and 20 cm distances from the leak source. If the maximum concentration observed at one of these distances was less than 100 ppmv, additional screening at greater distances was not required.

The method for determining the distance from the source provided a repeatable distance position without interfering with the pathway of the fugitive emissions from the source to the OVA probe tip. A thin brass (to avoid spark hazards) rod was attached to the OVA probe with rubber bands. The various distances were etched onto the rod, and for each distance, the rod tip was placed at the source, and the OVA probe was moved to locate the maximum concentration.

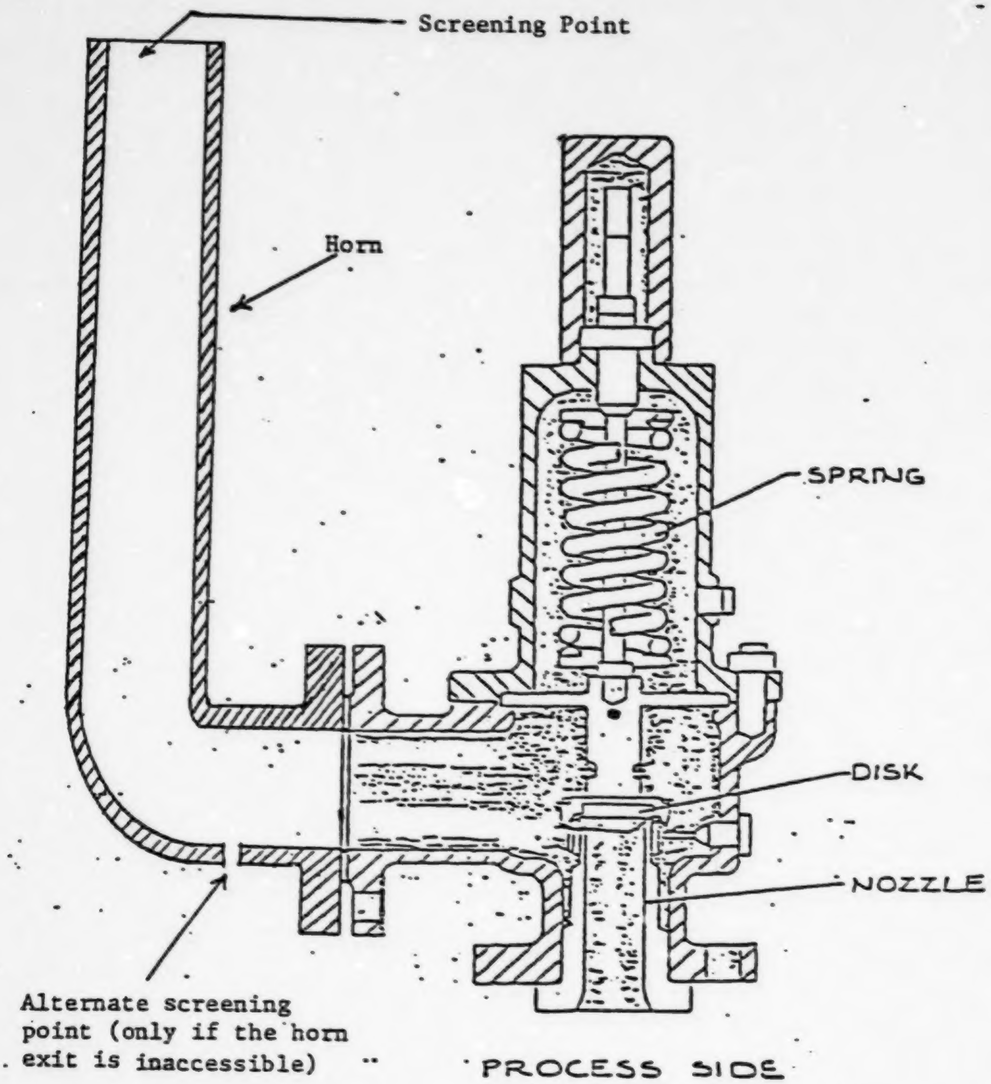

Screening Point
Horn
SPRING
DISK
NOZZLE
Alternate screening point (only if the horn exit is inaccessible)
PROCESS SIDE

Figure C-13. Diagram of a spring-loaded relief valve.

It should be noted that as the distance from the source increased, the surface to be traversed with the OVA probe increased as the distance squared. At distances greater than 2.5 cm. and in windy conditions, the maximum was usually found in one general direction from the source. No attempt was made to shield the wind from the source.

C.3 CALIBRATION PROCEDURES

The instrument used in this project was the OVA-108, produced by Century Systems. Calibration of the OVA was done to standard mixtures of methane in air. It was recognized that the response factors for various organic compounds measured with the hydrocarbon detectors would vary significantly, but it would have been quite expensive and cumbersome to carry calibration standards for the many organic mixtures encountered on a field program such as this.

Each OVA was subjected to the performance criteria test specified in EPA Method 21. This test was performed at the test site before the instruments were used to conduct leak surveys. In addition to the performance criteria, Method 21 also specifies calibration procedures. The description of procedures is generalized, and therefore specific details are described below.

Detailed calibration procedures that were performed daily are given in the following steps:

1. Battery charge and hydrogen pressure were checked.
2. The hydrogen tank was refilled or the battery was recharged as necessary.
3. The electronics, the sample pump, and the hydrogen flow were turned on.

4. The sample flow rate on the rotameter was checked and the system was checked for leaks by covering the probe tip. The sample flow fell from a reading of about 2 to near zero, and the pump sounded noticeably labored. Pump discharge leaks were checked by covering the detector exhaust port.

5. After about 10 minutes warm-up time, the internal electronic calibration points were checked. The "calibrate" knob set the high calibration at exactly 10,000 ppmv, and then the knob was switched to the low calibration to ensure that a reading of between 9 and 11 ppmv was obtained.

6. The hydrogen flame was ignited in the detector.

7. A leak-proof bag was filled with the higher standard calibration gas, which was about 8000 ppmv of methane in air. The contents of the bag were expelled to flush out any contaminants. This bag was clearly identified and reserved for this gas only. The bag was then refilled and fitted with a short length of Teflon tubing. The standard was introduced into the OVA. The reading was noted and recorded on the control chart. If the reading was off by more than ±5 percent, it was adjusted to read the exact value by turning the "calibrate" knob. The flame was then extinguished and the electronic calibration was adjusted using the "gas select" knob. The new "gas select" knob reading was recorded.

8. The calibration on the low range (500 ppmv) standard gas was then checked. A bag was filled with the standard, purged, and refilled. The concentration as determined by the OVA was then read. If the concentration was within ±20 percent of the standard concentration, the reading was recorded and screening proceeded. If the variation was between ±20 and ±40 percent, the calibration was readjusted to split the error evenly between the high and low standards. The electronic standards were readjusted using the "gas select" knob.

9. The dilution probe was calibrated daily and the carbon pack was changed weekly. To calibrate the dilution probe, a bag was filled with the high standard and the concentration read with the dilution probe attached to the OVA. This reading was recorded on the control charts, and then the pinch clamp on the dilution air line was adjusted until it read exactly a 10 to 1 dilution.

APPENDIX D
QUALITY CONTROL RESULTS

Procedures were followed to ensure the quality of the collected data. These procedures included Method 21 instrument performance evaluation, instrument calibration checks, repeated screening of certain sources, and screening quality assurance audits.

Five (5) Century Systems Organic Model OVA-108 hydrocarbon detectors were used to screen sources. Instrument identification is described below:

Contractor	Century Systems Serial Number	Assigned I.D. Number
Radian Corporation	C5797	2
	C5794	3
	C5799	5
GCA Corporation	C4900	0
	C5795	1
	C5797	2

D.1 METHOD 21 INSTRUMENT PERFORMANCE EVALUATION PROCEDURES

The results of the calibration precision test and the response time procedure for the Method 21 instrument performance evaluation are shown in Tables D-1 and D-2 for the Chevron and Powerine refinery screening programs, respectively.

D.2 INSTRUMENT CALIBRATION CHECKS

The instruments were calibrated each day. Standards of 800 ppmv and 8,000 ppmv methane in air were used to obtain an instrument reading in the morning (AM reading) and again in the afternoon (PM reading) after the completion of screening activities and before instrument recalibration. In addition to performing low and high standard calibrations, a dilution probe

TABLE D-1

METHOD 21 PERFORMANCE CHECKS
CHEVRON

Instrument ID #62 C5797 2/11/81

Calibration Gas Concentration 8000

90% Response Time:

1. 3 Seconds

2. 2 Seconds

3. 3 Seconds

Mean Response Time 2.67 Seconds

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #62 C5797 2/11/81

Calibration Gas Concentration 8000 w/dilution probe
10:1 dilution

90% Response Time:

1. 6 Seconds

2. 6 Seconds

3. 5 Seconds

Mean Response Time 5.67 Seconds

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #62 C5797 2/11/81

Calibration Gas Data

Calibration = 8000 ppmv

Run No.	Instrument Meter Reading, ppm	Difference[1] ppm
1.	8100	-100
2.	8000	0
3.	7800	200
4.	8000	0
5.	7000	1000
6.	7900	100
7.	8100	-100
8.	8300	-300
9.	7900	100

Mean Difference 100

Calibration Precision = $\frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}} \times 100$ 1.25

---

(1) Calibration Gas Concentration - Instrument Reading

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TABLE D-1 (continued)

Instrument ID #63 C 5794 2/11/81

Calibration Gas Concentration 8000

90% Response Time:

1. 5 Seconds

2. 7 Seconds

3. 3 Seconds

Mean Response Time 5 Seconds

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #63 C 5794 2/11/81

Calibration Gas Concentration 8000 w/ dilution probe
10:1 dilution

90% Response Time:

1. 8 Seconds
2. 5 Seconds
3. 5 Seconds

Mean Response Time 6 Seconds

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #63 C5794 2/11/81

Calibration Gas Data

Calibration = 8000 ppmv

Run No.	Instrument Meter Reading, ppm	Difference[1] ppm
1.	7800	200
2.	7800	200
3.	8000	0
4.	8000	0
5.	8000	0
6.	8000	0
7.	8000	0
8.	7800	200
9.	7900	100
Mean Difference		77.8
Calibration Precision = $\frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}} \times 100$		0.97

---

(1) Calibration Gas Concentration - Instrument Reading

Reproduced from best available copy.

TABLE D-1 (continued)

Instrument ID #62 C 5797 3/2/81

Calibration Gas Concentration 8000

90% Response Time:

1. 2.3 Seconds
2. 2.7 Seconds
3. 2.5 Seconds

Mean Response Time 2.5 Seconds

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #62 C 5797 3/2/81

Calibration Gas Concentration 8000 w/ dilution probe 10.1 dilution

90% Response Time:

1. 3.7 Seconds
2. 3.7 Seconds
3. 3.6 Seconds

Mean Response Time 3.67 Seconds

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #62 C5797 3/2/81

Calibration Gas Data

Calibration = 8000 ppmv

Run No.	Instrument Meter Reading, ppm	Difference(1) ppm
1.	8800	-800
2.	8900	-900
3.	9000	-1000
4.	8800	-800
5.	9100	-1100
6.	9000	-1000
7.	9100	-1100
8.	9000	-1000
9.	9200	-1200
Mean Difference		-988.9

Calibration Precision = $\frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}}$ x 100 12.4

---

(1) Calibration Gas Concentration - Instrument Reading

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TABLE D-1 (continued)

Instrument ID #63 C5794 3/2/81

Calibration Gas Concentration 8000

90% Response Time:

1. 3.1 Seconds
2. 3.2 Seconds
3. 3.5 Seconds

Mean Response Time 3.27 Seconds

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #63 C5794 3/2/81

Calibration Gas Concentration 8000 w/dilution probe
10.1 dilution

90% Response Time:

1. 4.2 Seconds

2. 4.0 Seconds

3. 4.3 Seconds

Mean Response Time 4.17 Seconds

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #63 C5794 3/2/81

Calibration Gas Data

Calibration = 8000 ppmv

Run No.	Instrument Meter Reading, ppm	Difference(1) ppm
1.	8800	-8000
2.	9400	-1400
3.	9000	-1000
4.	9000	-1000
5.	9000	-1000
6.	9000	-1000
7.	9000	-1000
8.	9000	-1000
9.	8900	-900

Mean Difference -1011

Calibration Precision = $\frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}} \times 100$ 12.6

---

(1) Calibration Gas Concentration - Instrument Reading

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TABLE D-1 (continued)

Instrument ID #65 C 5799 3/2/81

Calibration Gas Concentration 8000

90% Response Time:	
1. 2.5 Seconds	
2. 2.9 Seconds	
3. 3.1 Seconds	
Mean Response Time 2.83 Seconds	

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #65 C5799 3/2/81

Calibration Gas Concentration 8000 w/ dilution probe
10:1 dilution

90% Response Time:

1. 3.5 Seconds

2. 3.8 Seconds

3. 3.6 Seconds

Mean Response Time 3.63 Seconds

RESPONSE TIME DETERMINATION

TABLE D-1 (continued)

Instrument ID #65 C5799 3/2/81

Calibration Gas Data

Calibration = 8000 ppmv

Run No.	Instrument Meter Reading, ppm	Difference(1) ppm
1.	8700	-700
2.	8700	-700
3.	9000	-1000
4.	9100	-1100
5.	9400	-1400
6.	9300	-1300
7.	9300	-1300
8.	9400	-1400
9.	9400	-1400

Mean Difference - 1144

Calibration Precision = $\frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}} \times 100$ 14.3

---

(1) Calibration Gas Concentration - Instrument Reading

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TABLE D-2

METHOD 21 PERFORMANCE CHECKS
POWERINE

Instrument ID #11 C5795 3/4/81

Calibration Gas Concentration 8130

90% Response Time:

1. 2 Seconds
2. 2.5 Seconds
3. 2.5 Seconds

Mean Response Time 2.33 Seconds

RESPONSE TIME DETERMINATION

TABLE D-2 (continued)

Instrument ID #11 C5795

3/4/81

Calibration Gas Concentration 8130 w/dilution probe
10·1 dilution

90% Response Time:

1. 3.0 Seconds
2. 3.5 Seconds
3. 3.5 Seconds

Mean Response Time 3.33 Seconds

RESPONSE TIME DETERMINATION

TABLE D-2 (continued)

3/4/81
w/ dilution probe
10 · 1 dilution

Instrument ID #11 C5795

Calibration Gas Data

Calibration = 8130 ppmv

Run No.	Instrument Meter Reading, ppm	Difference[1] ppm
1.	800	13
2.	800	13
3.	800	13
4.	800	13
5.	800	13
6.	800	13
7.	800	13
8.	800	13
9.	800	13

Mean Difference 13

Calibration Precision = $\frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}} \times 100$ 1.6

---

(1) Calibration Gas Concentration - Instrument Reading

CALIBRATION PRECISION DETERMINATION

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TABLE D-2 (continued)

3/4/81
w/o dilution probe
H_2 press - 9 psi

Instrument ID #11 C5795

Calibration Gas Data

Calibration = 8130 ppmv

Run No.	Instrument Meter Reading, ppm	Difference[(1)] ppm
1.	8000	130
2.	8100	30
3.	8100	30
4.	8000	130
5.	8100	30
6.	8000	130
7.	8000	130
8.	8000	130
9.	8100	30

Mean Difference 85.6

Calibration Precision = $\frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}} \times 100$ 1.05

---

(1) Calibration Gas Concentration - Instrument Reading

CALIBRATION PRECISION DETERMINATION

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TABLE D-2 (continued)

Instrument ID #10 C4900 3/4/81

Calibration Gas Concentration 8130 w/dilution probe 10.1 dilution

90% Response Time:

1. 3.5 Seconds
2. 3.5 Seconds
3. 3.0 Seconds

Mean Response Time 3.33 Seconds

RESPONSE TIME DETERMINATION

TABLE D-2 (continued)

Instrument ID #10 C4900 3/4/81

Calibration Gas Concentration .8130

90% Response Time:

1. 2.0 Seconds

2. 2.0 Seconds

3. 2.0 Seconds

Mean Response Time 2.0 Seconds

RESPONSE TIME DETERMINATION

TABLE D-2 (continued)

Instrument ID #10 C4900

3/4/81
w/ dilution probe
10:1 dilution

Calibration Gas Data

Calibration = 8130 ppmv

Run No.	Instrument Meter Reading, ppm	Difference[(1)] ppm
1.	800	13
2.	800	13
3.	800	13
4.	850	37
5.	800	13
6.	800	13
7.	800	13
8.	800	13
9.	800	13

Mean Difference 15.67

Calibration Precision = $\frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}} \times 100$ 1.96

---

(1) Calibration Gas Concentration - Instrument Reading

CALIBRATION PRECISION DETERMINATION

TABLE D-2 (continued)

Instrument ID #10 C+900 3/4/81

Calibration Gas Data

Calibration = 8130 ppmv

Run No.	Instrument Meter Reading, ppm	Difference(1) ppm
1.	8000	130
2.	8000	130
3.	8100	30
4.	8000	130
5.	8000	130
6.	8000	130
7.	8000	130
8.	8000	130
9.	8300	170
Mean Difference		123.33

$$\text{Calibration Precision} = \frac{\text{Mean Difference}}{\text{Calibration Gas Concentration}} \times 100 \quad 1.52$$

---

(1) Calibration Gas Concentration - Instrument Reading

CALIBRATION PRECISION DETERMINATION

Reproduced from best available copy.

fitted to the instrument detector probe was adjusted for a 10:1 dilution of the high standard each morning and afternoon. A dilution factor was calculated where:

$$\text{Dilution factor} = \frac{\text{Reading using 8,000 ppmv standard}}{\begin{array}{c}\text{Reading using 8,000 ppmv standard}\\ \text{with dilution probe}\end{array}}$$

The percent difference between the AM and PM readings was calculated as follows:

$$\text{Percent difference} = \frac{\text{PM value - AM value}}{\text{AM value}} \times 100\%$$

Figures D-1 through D-9 show the percent differences obtained each day by each instrument used at the Chevron refinery when calibrated with the high standard, the low standard, and the high standard with the dilution probe attached. Figures D-10 through D-12 show similar calibration results for the Powerine refinery screening survey.

Tables D-3 and D-4 show the mean percent differences for the instruments calibrated with the high standard, the low standard, and the high standard with the dilution probe attached at the Chevron and Powerine refineries, respectively. Results are not shown in Table D-4 for the calibration of instruments number 0 and number 2 at the Powerine refinery since each of these instruments was used only one day.

D.3 REPEATED SCREENING

Three values were selected at each refinery for daily screening to determine screening repeatability. Three readings were obtained for each value within a 30-minute period each day. Fig. D-13 through D-18 show screening value trends for these valves at the Chevron and Powerline refineries. Symbols

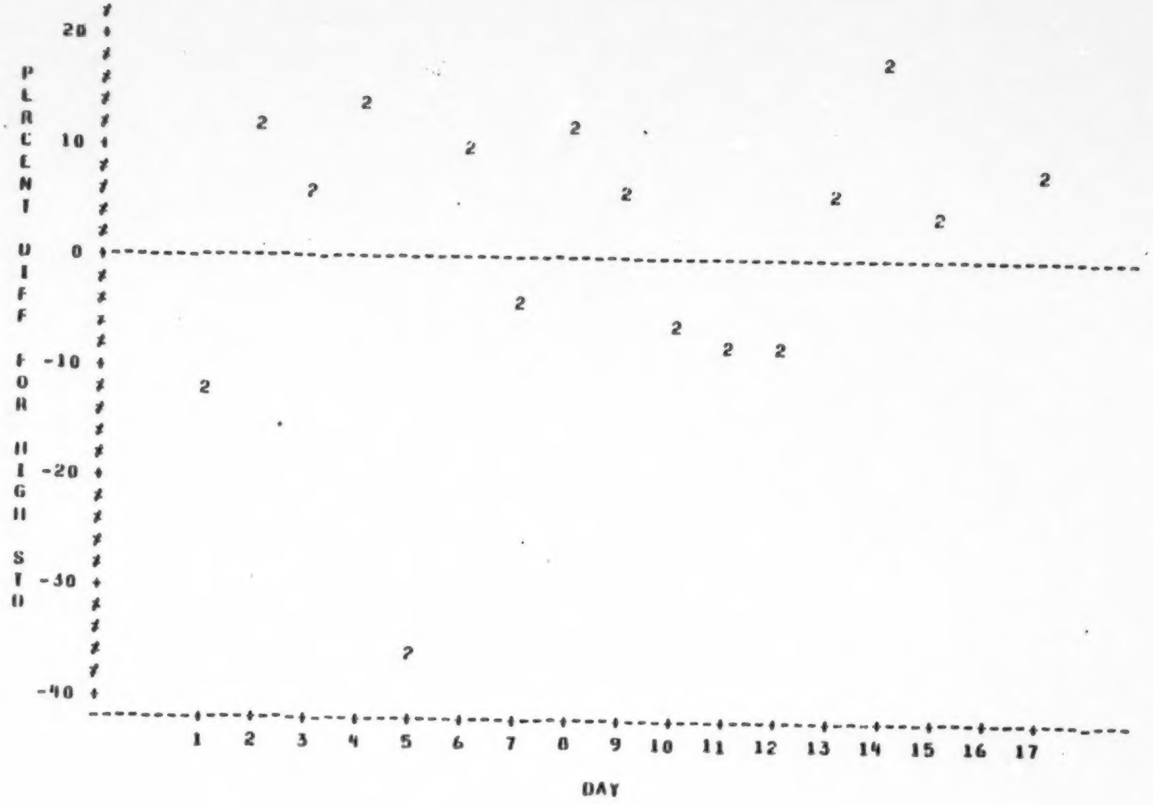


FIGURE D-1
PERCENT DIFFERENCES FOR CALIBRATION CHECKS - HIGH STANDARD
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
INSTRUMENT NUMBER = 2
CHEVRON

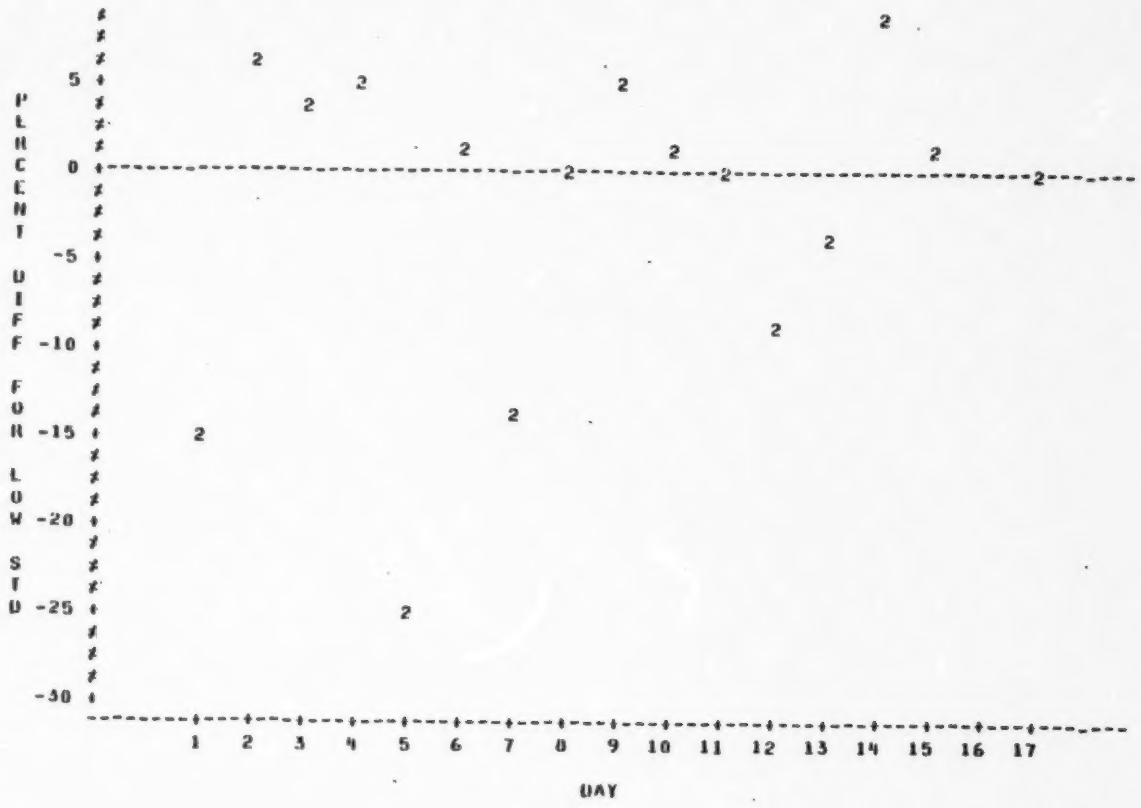


FIGURE D-2
PERCENT DIFFERENCES FOR CALIBRATION CHECKS - LOW STANDARD
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
INSTRUMENT NUMBER = 2
CHEVRON

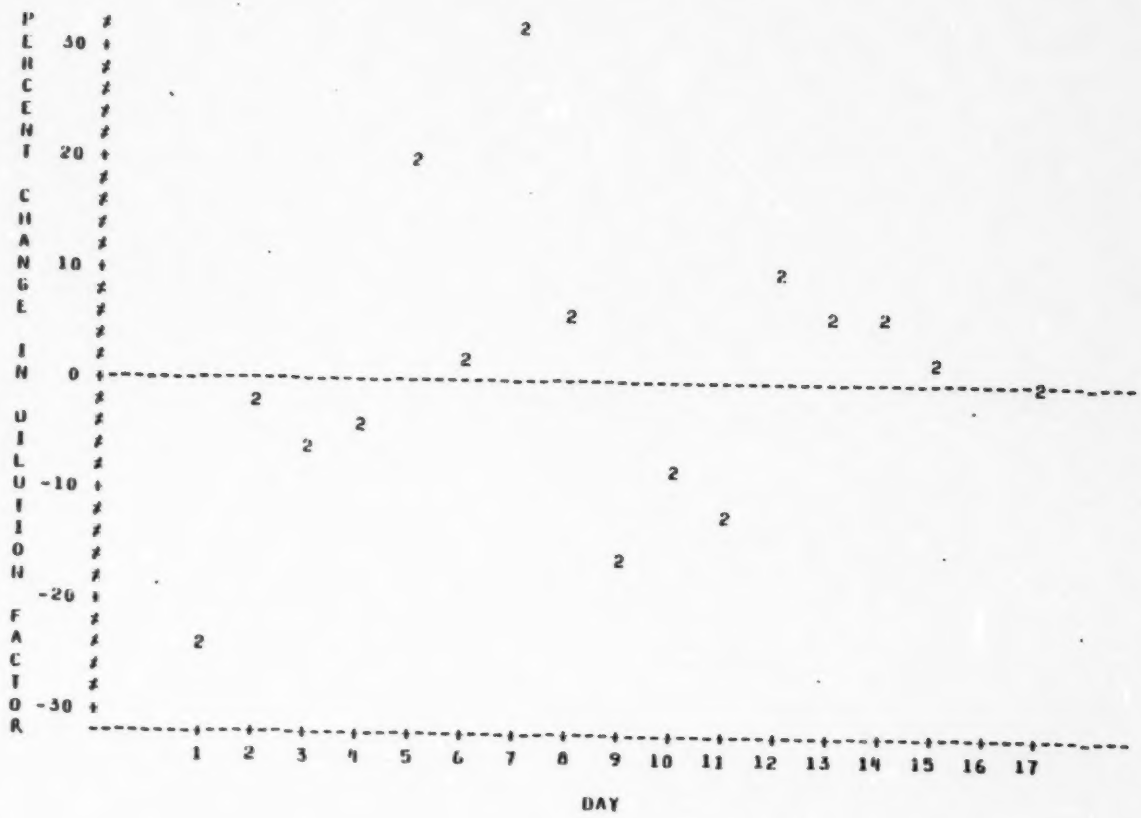


FIGURE D-3
PERCENT CHANGES IN DILUTION FACTOR
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
INSTRUMENT NUMBER = 2
CHEVRON

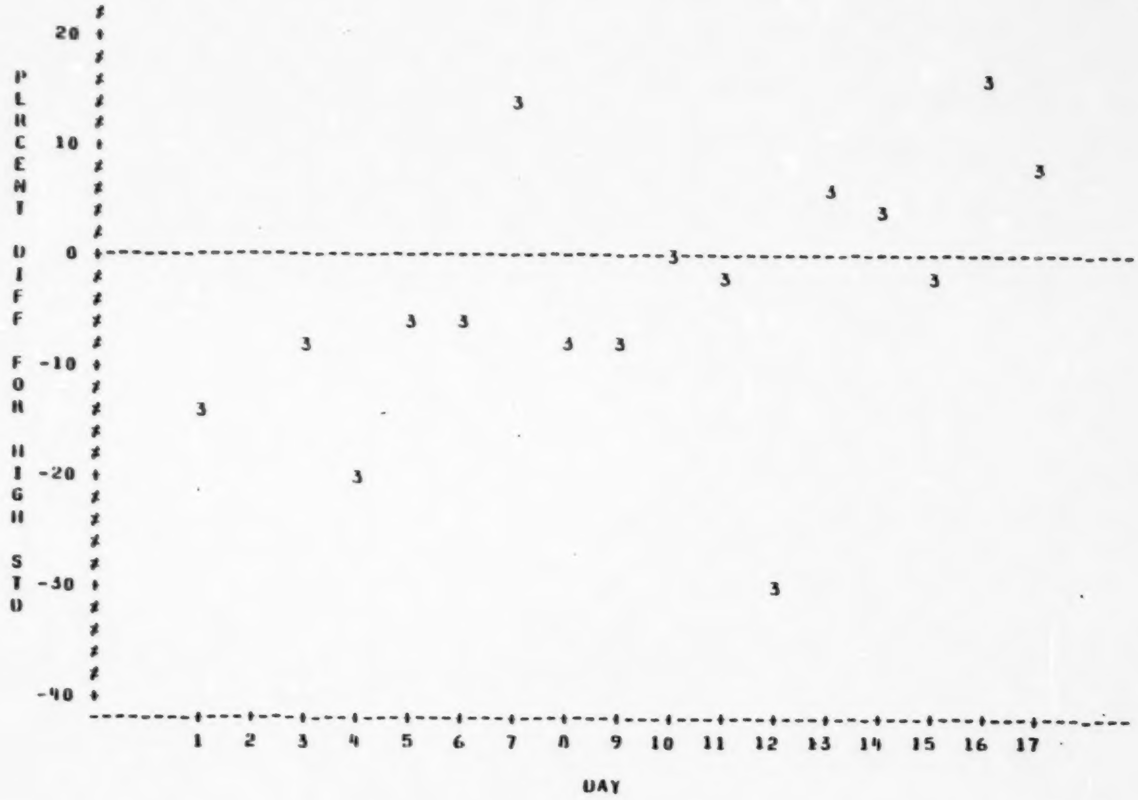


FIGURE D-4
PERCENT DIFFERENCES FOR CALIBRATION CHECKS - HIGH STANDARD
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
INSTRUMENT NUMBER = 3
CHEVRON

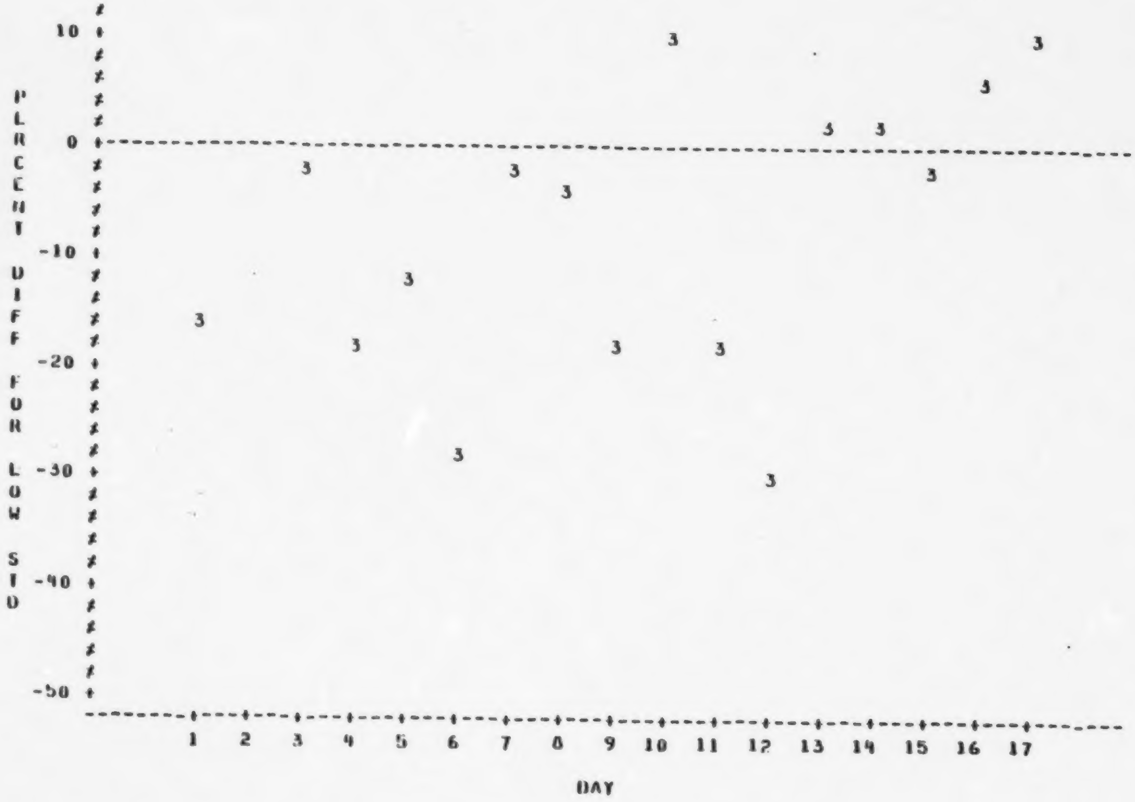


FIGURE D-5
PERCENT DIFFERENCES FOR CALIBRATION CHECKS - LOW STANDARD
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
INSTRUMENT NUMBER = 3
CHEVRON

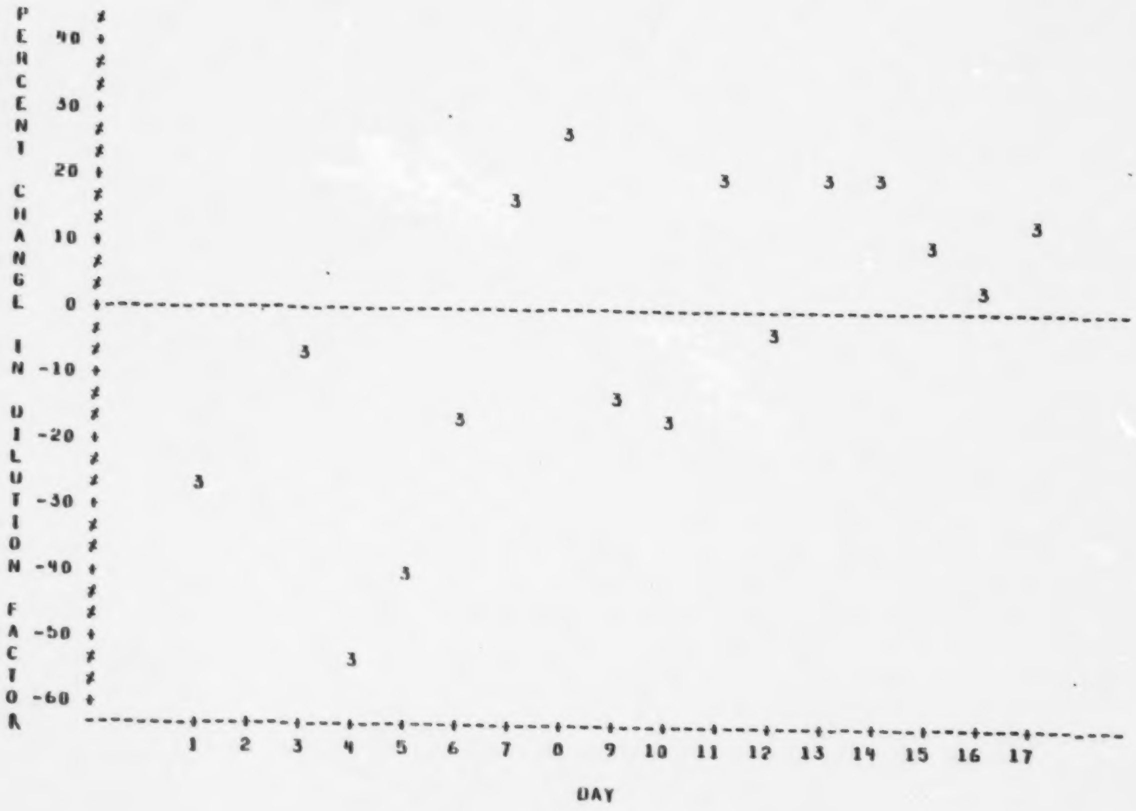


FIGURE D-6
PERCENT CHANGES IN DILUTION FACTOR
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
INSTRUMENT NUMBER = 3
CHEVRON

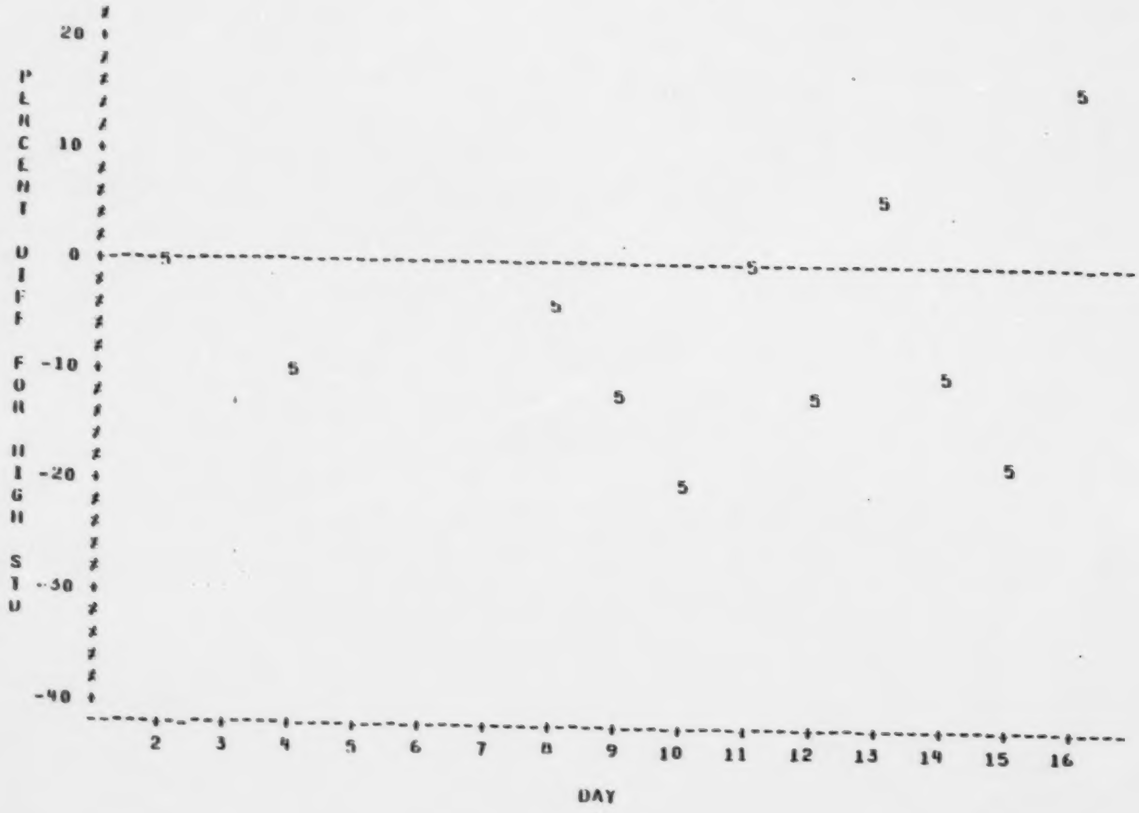


FIGURE D-7
PERCENT DIFFERENCES FOR CALIBRATION CHECKS - HIGH STANDARD
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
INSTRUMENT NUMBER = 5
CHEVRON

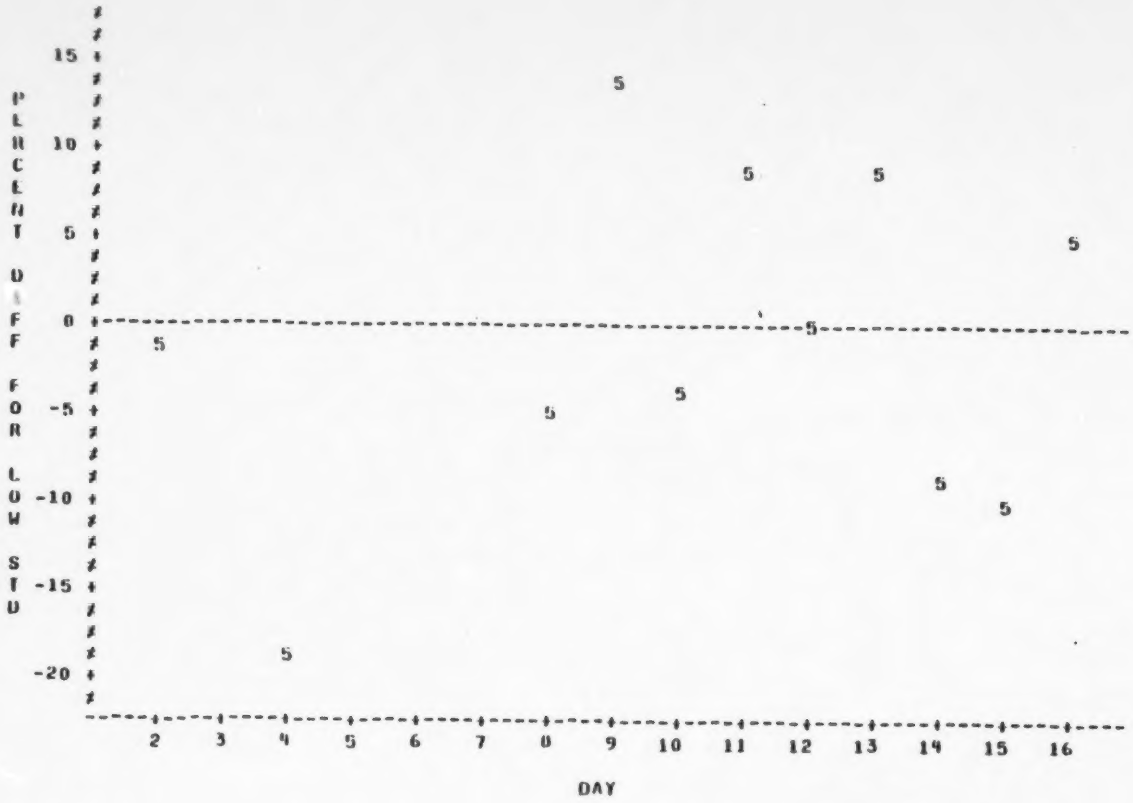
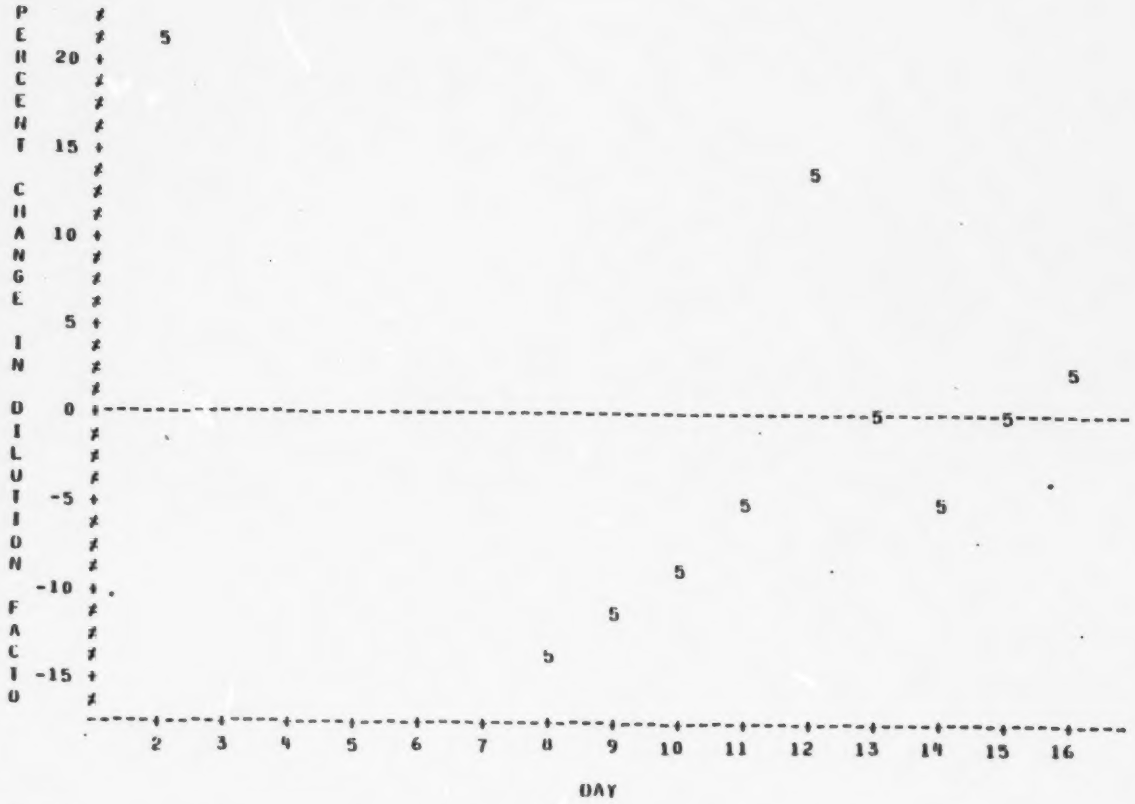


FIGURE D-8
PERCENT DIFFERENCES FOR CALIBRATION CHECKS - LOW STANDARD
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
INSTRUMENT NUMBER = 5
CHEVRON



NOTE: 1 OBS HAD MISSING VALUES

FIGURE D-9
PERCENT CHANGES IN DILUTION FACTOR
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
INSTRUMENT NUMBER = 5
CHEVRON

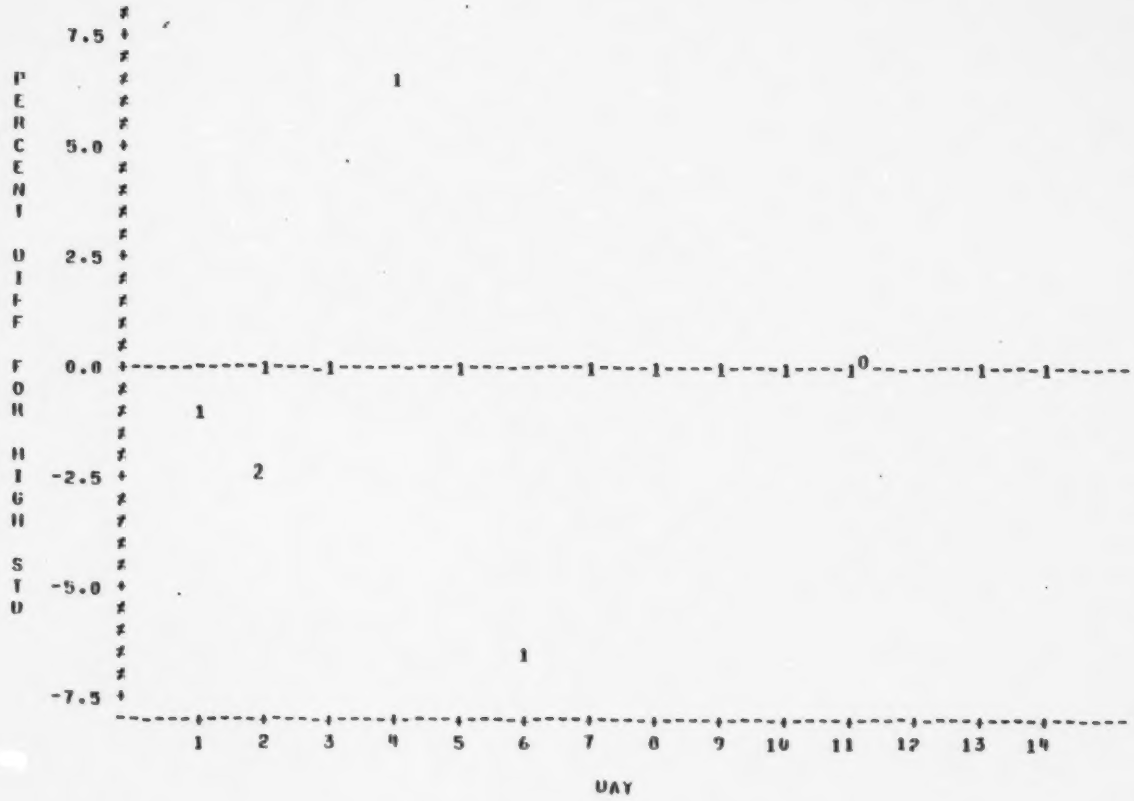


FIGURE D-10
PERCENT DIFFERENCES FOR CALIBRATION CHECKS - HIGH STANDARD
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
POWERINE

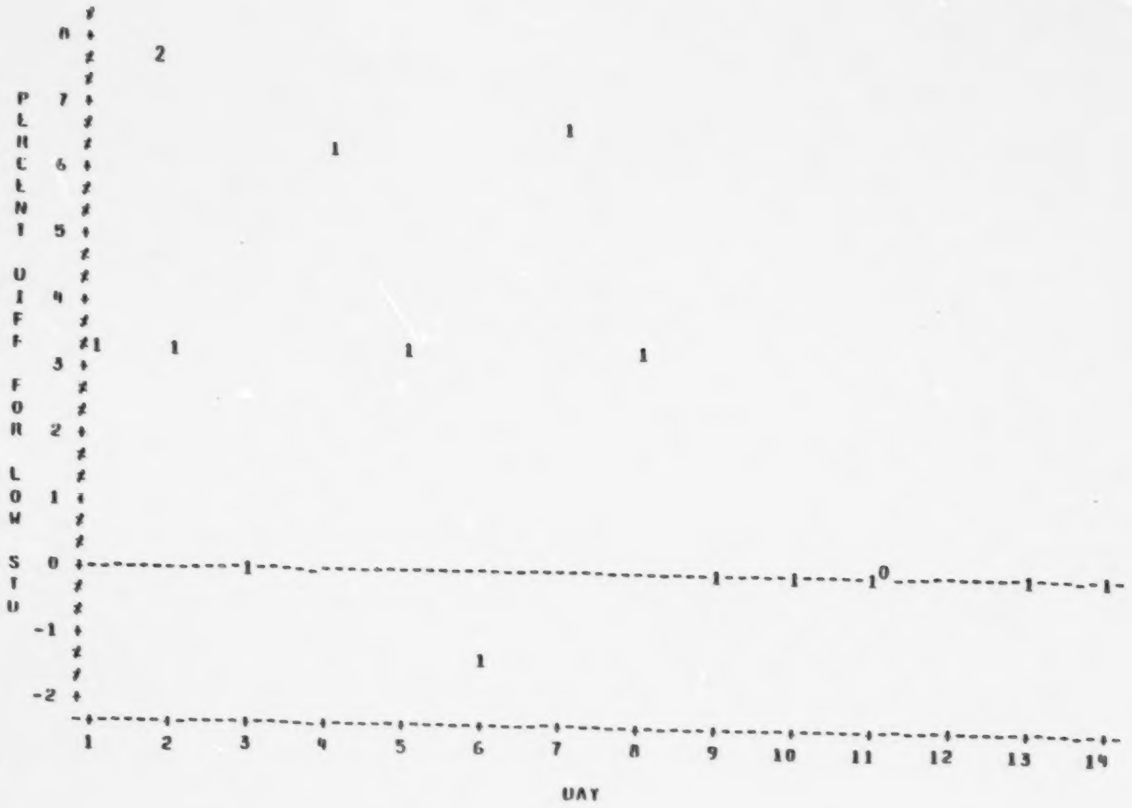


FIGURE D-11
PERCENT DIFFERENCES FOR CALIBRATION CHECKS - LOW STANDARD
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
POWERINE

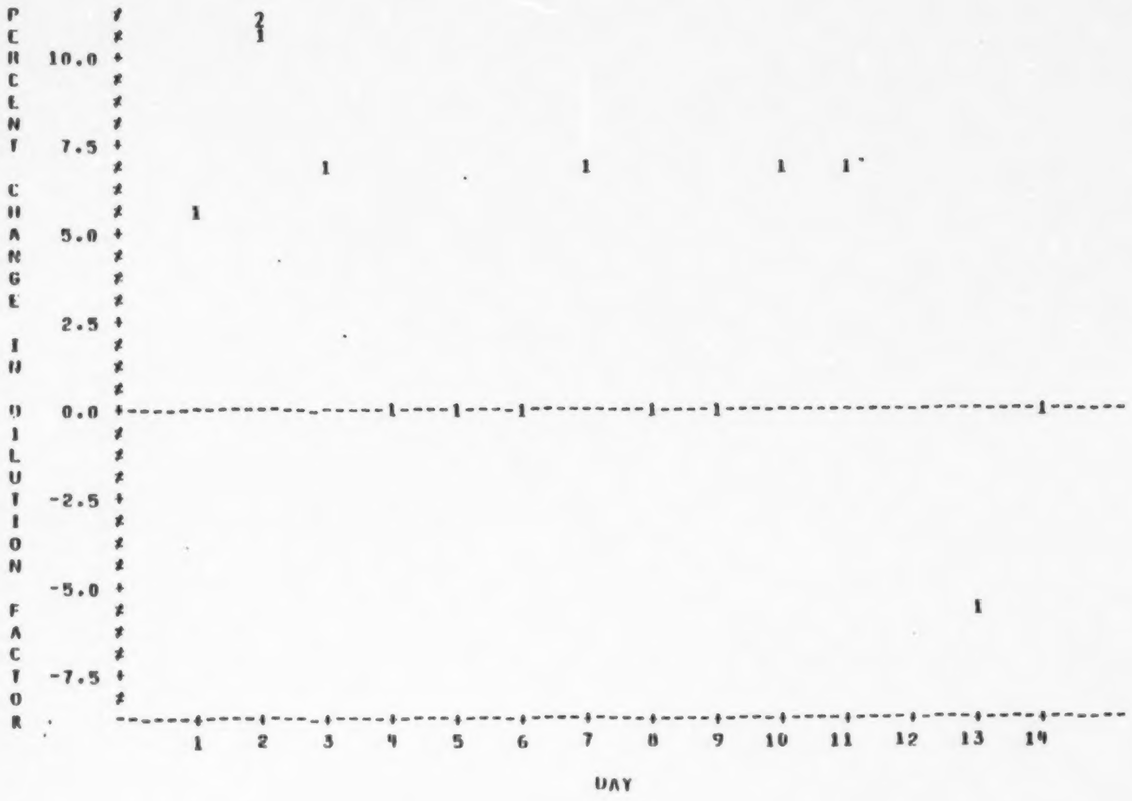


FIGURE D-12
PERCENT CHANGES IN DILUTION FACTOR
LEGEND: SYMBOL = INSTRUMENT ID NUMBER
POWERINE

TABLE D-3

SUMMARY OF MEAN PERCENT DIFFERENCE BETWEEN MORNING (AM) AND AFTERNOON (PM) READING USING A LOW STANDARD, HIGH STANDARD, AND DILUTION FACTOR FOR EACH INSTRUMENT

CHEVRON

Standard	Instrument	Mean Percent Difference[1]	Number of Days	95 Percent Confidence Interval
Low-800 ppmv	2	-2.03	16	(-6.46, 2.40)
	3	-7.61	16	(-13.82,-1.40)
	5	-0.93	11	(-6.55, 4.69)
High-8000 ppmv	2	1.49	16	(-5.01, 7.99)
	3	-3.73	16	(-9.66, 2.20)
	5	-5.80	11	(-12.14, 0.53)
Dilution Factor[2]	2	0.85	16	(-5.76, 7.47)
	3	-3.12	16	(-14.56, 8.32)
	5	-0.74	10	(-7.57, 6.09)

---

[1] Percent Difference = $\frac{\text{PM value - AM value}}{\text{AM reading}} \times 100$.

[2] Dilution Factor = $\frac{\text{Reading using 8000 ppmv standard}}{\text{Reading using 8000 ppmv with dilution probe}}$.

TABLE D-4

SUMMARY OF MEAN PERCENT DIFFERENCE BETWEEN MORNING (AM) AND AFTERNOON (PM) READING USING A LOW STANDARD, HIGH STANDARD, AND DILUTION FACTOR FOR INSTRUMENT NUMBER 1

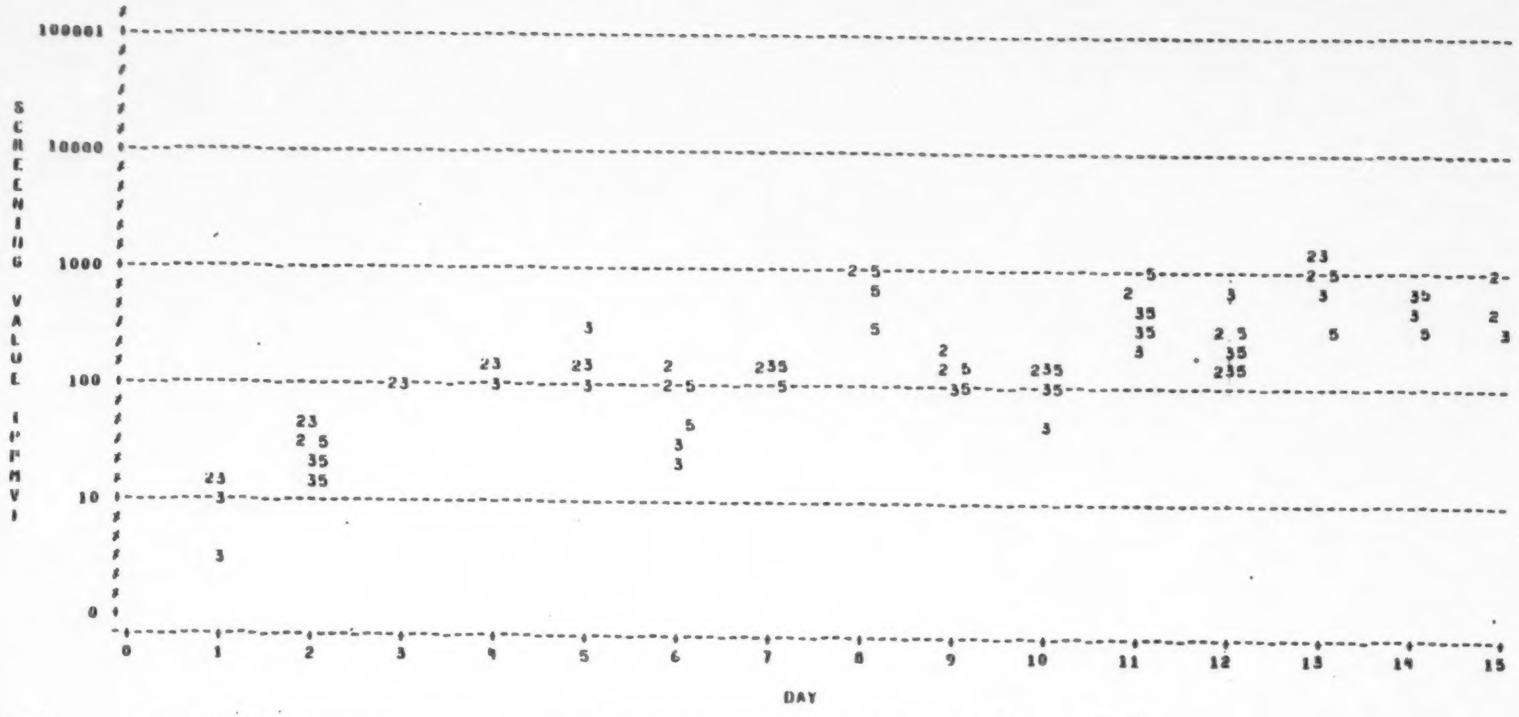
POWERINE

Standard	Instrument	Mean Percent Difference[1]	Number of Days	95 Percent Confidence Interval
Low-800 ppmv	1	1.919	13	(0.480, 3.357)
High-8000 ppmv	1	-0.095	13	(-1.494, 1.305)
Dilution Factor[2]	1	2.809	13	(0.335, 5.283)

---

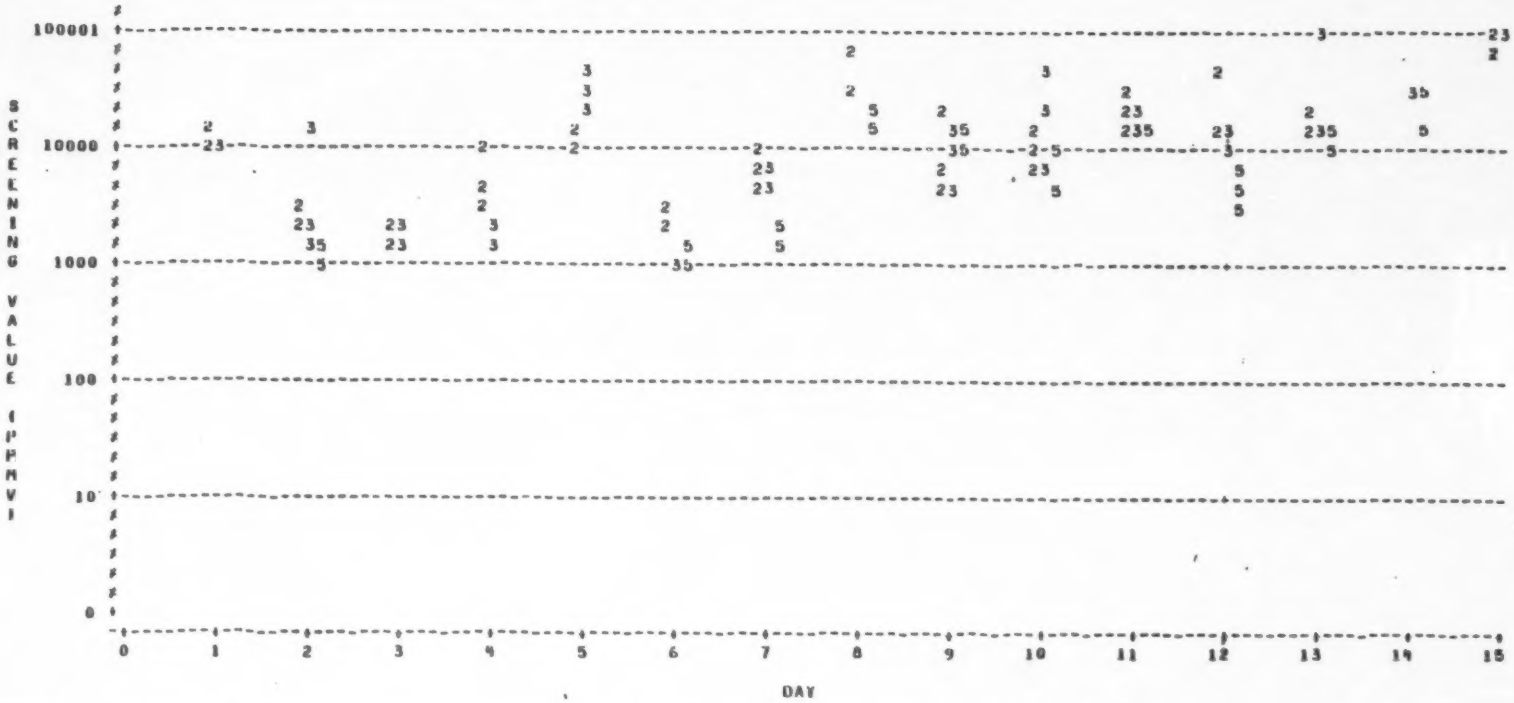
[1] Percent Difference = $\frac{\text{PM value - AM value}}{\text{AM value}} \times 100$.

[2] Dilution Factor = $\frac{\text{Reading using 8000 ppmv standard}}{\text{Reading using 8000 ppmv with dilution probe}}$.



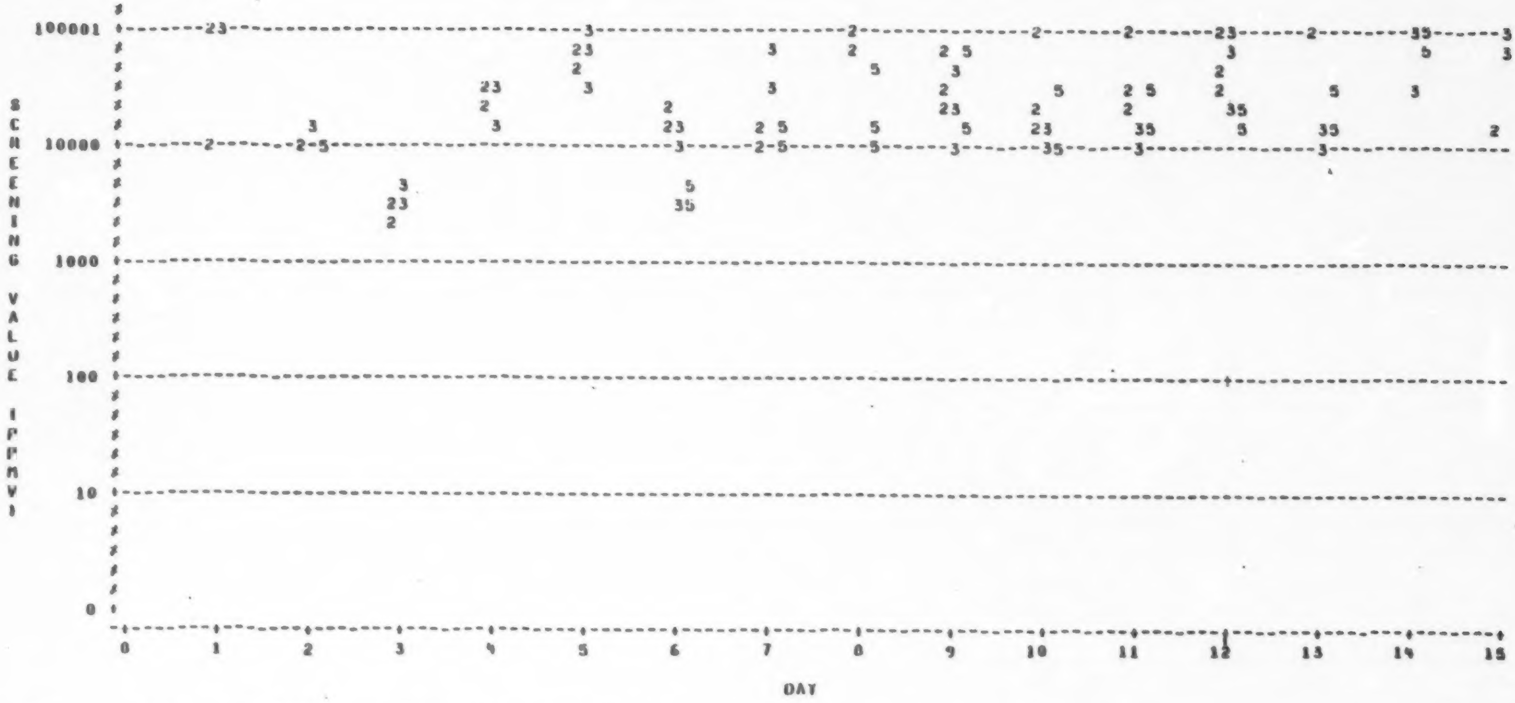
NOTE: 40 OBS HIDDEN (same instrument at approximately the same screening value on the same day)

FIGURE D-13
REPEAT SCREENING TREND CHART
LEGEND: SYMBOL IS INSTRUMENT NUMBER
VALVE = 1218
CHEVRON



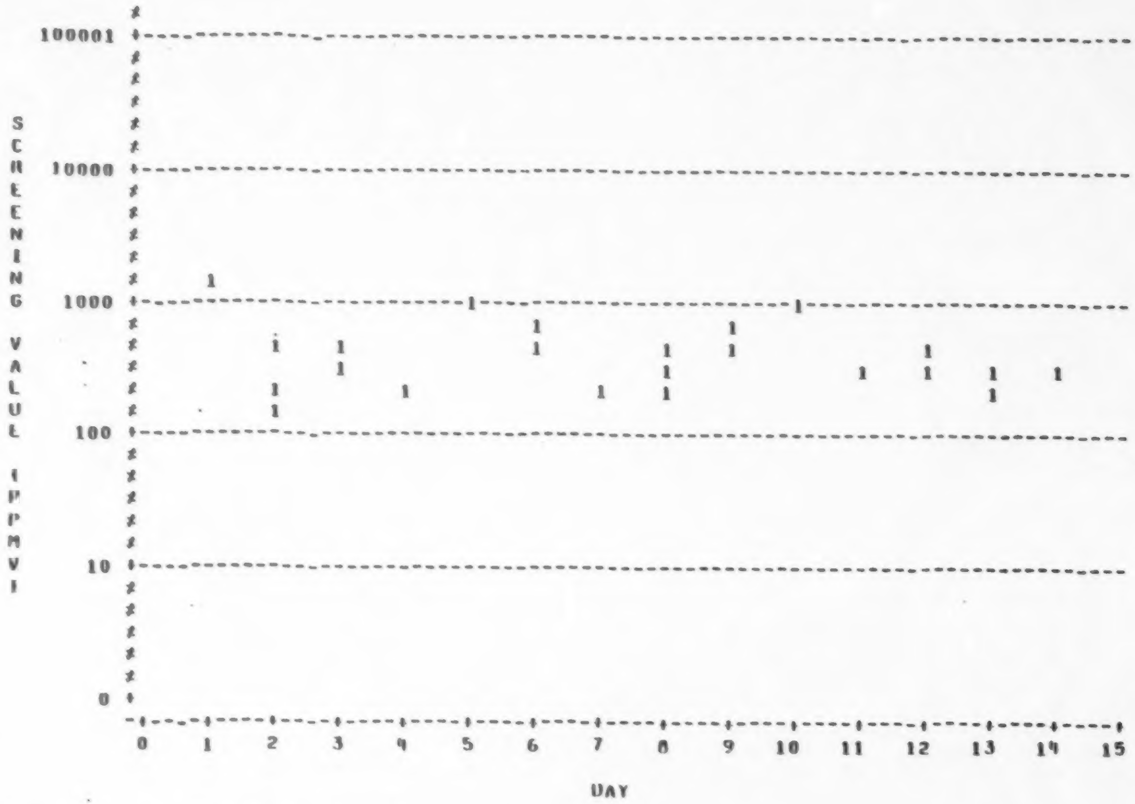
NOTE: 33 OBS HIDDEN (same instrument at approximately the same screening value on the same day)

FIGURE D-14
REPEAT SCREENING TREND CHART
LEGEND: SYMBOL IS INSTRUMENT NUMBER
VALVE = 1124
CHEVRON



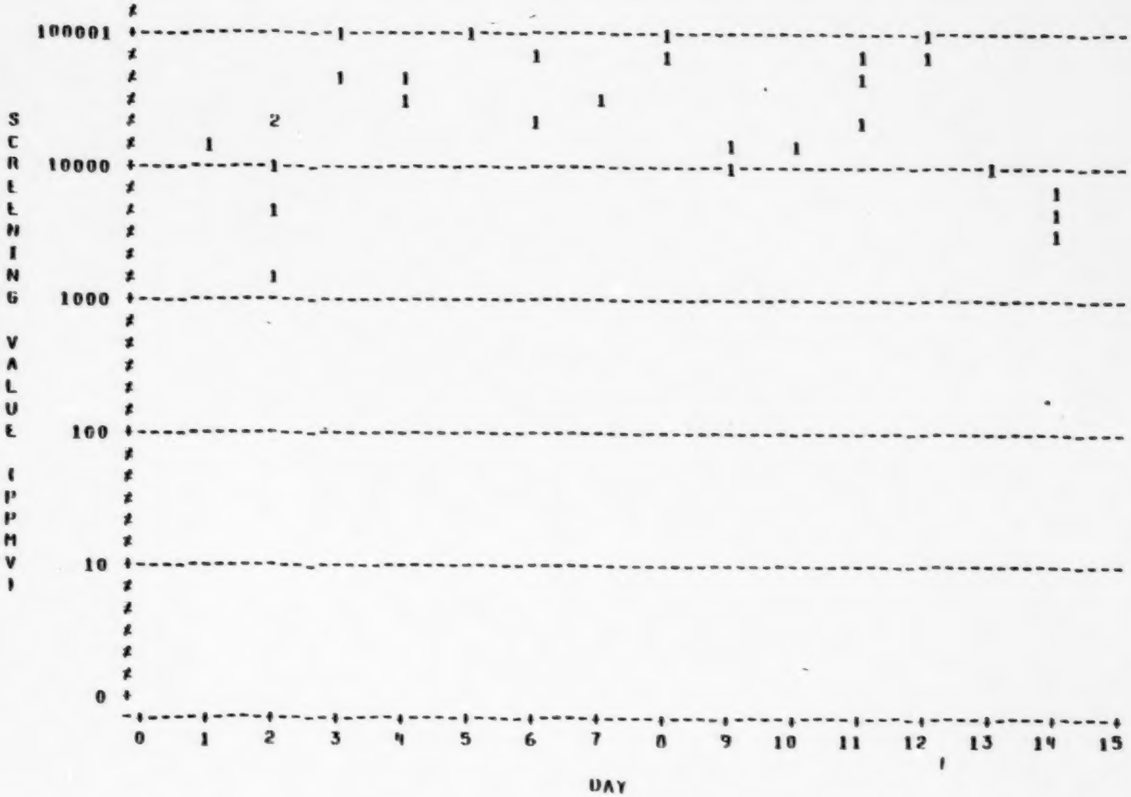
NOTE: 35 OBS HIDDEN (same instrument at approximately the same screening value on the same day)

FIGURE D-15
REPEAT SCREENING TREND CHART
LEGEND: SYMBOL IS INSTRUMENT TREND CHART
VALVE = 1200
CHEVRON



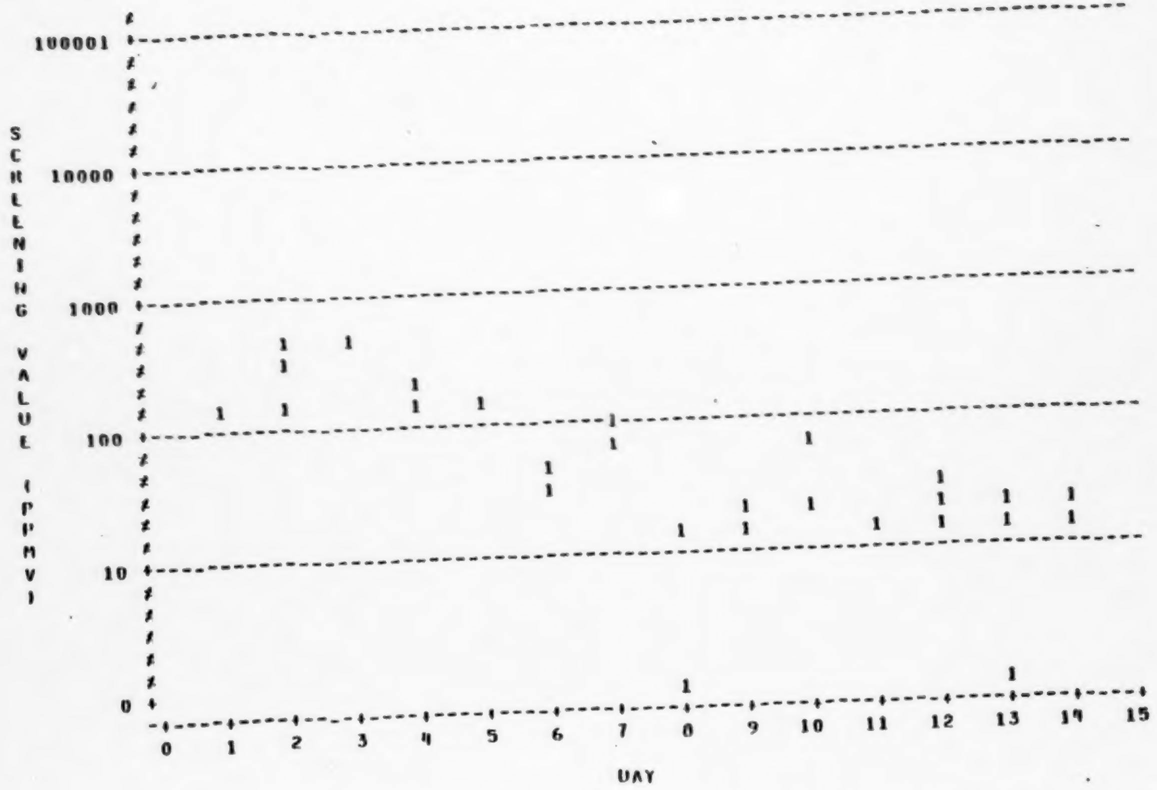
NOTE: 19 OBS HIDDEN (Same instrument at approximately the same screening value on the same day)

FIGURE D-16
REPEAT SCREENING TREND CHART
LEGEND: SYMBOL IS INSTRUMENT NUMBER
VALVE = 1001
POWERINE



NOTE: 15 OBS HIDDEN (Same Instrument at approximately the same screening value on the same day)

FIGURE D-17
REPEAT SCREENING TREND CHART
LEGEND: SYMBOL IS INSTRUMENT NUMBER
VALVE = 1016
POWERINE



NOTE: 15 OBS HIDDEN (Same instrument at approximately the same screening value on the same day)

FIGURE D-18
REPEAT SCREENING TREND CHART
LEGEND: SYMBOL IS INSTRUMENT NUMBER
VALVE = 1066

POWERINE

that are used to indicate screening value are the instrument assigned I.D. numbers. If screening values measured by one instrument on a particular day are equal, one value is plotted while the others are "hidden."

The variation between screening values is the sum of the components due tobetween valve variation, between day variation within valves, between instrument/screener variation within valves and day (at only the Chevron refinery, where more than one screening team operated), and between repeated readings. A variance component analysis was performed to estimate the contribution to the total variation by these variation sources.

Table D-5 shows that 83.9 percent of the total variation in screening values for the repeat screening valves at the Chevron refinery is due to variation between valves. The between day variation of the values represents 11.2 percent of the total variation. Only 2.7 percent and 2.2 perdent of the variation is due toinstrument/screener and repeated readings, respectively. When only the variation within a valve is considered, 69.7 percent of the remaining variation is due to between day variation.

The repeat screening variance component was 0.033 log $(\text{ppmv})^2$ giving a repeat screening standard deviation of 0.18 log ppmv. A 95 percent variance multiplier* calculated from this component is 2.3. This multiplier means that repeat screening values of a source with a mean screening value of x could be expected to range from $\frac{x}{2.3}$ to 2.3x.

Table D-6 indicates that 88.6 percent of the total variation in screening values for the repeat screening valves at the Powerine refinery

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*Variance multiplier = $10^{1.96(0.18)}$

TABLE D-5

VARIANCE COMPONENT ESTIMATES FOR SCREENING MEASUREMENTS

CHEVRON

Log_{10} (Screening Value)

Source of Variation	Degrees of Freedom	Variance Component Estimate $\text{Log}_{10}\ (\text{ppmv})^2$	Percent of Total Variation	Percent of Variation Within Valves
Total	341	1.518	100.0	
Valves	2	1.274	83.9	100.0
Day-to-day within valves	42	0.170	11.2	69.7
Instrument-Screener within days and valves	69	0.042	2.7	17.2
Between Repeated Screenings	228	0.033	2.2	13.5

TABLE D-5

VARIANCE COMPONENT ESTIMATES FOR SCREENING MEASUREMENTS

POWERINE
Log_{10} (Screening Value)

Source of Variation	Degrees of Freedom	Variance Component Estimate Log_{10} (ppmv)^2	Percent of Total Variation	Percent of Variation Within Valves
Total	125	2.051	100.0	
Valves	2	1.818	88.6	100.0
Day-to-day within valves	42	0.183	8.9	78.3
Between repeated screenings	81	0.051	2.5	21.7

is due to variation between valves. The between day variation of the values results in 8.9 percent of the total variation. Only 2.5 percent of the variation is due to repeated readings. When only the variation within a value is considered, 78.3 percent of the remaining variation is due to between day variation.

The repeat screening variance component was 0.051 log $(\text{ppmv})^2$ giving a repeat screening standard deviation of 0.23 log ppmv. A 95 percent variance multiplier* calculated from this component is 2.8. This multiplier means that repeat screening values of a source with a mean screening value of x could be expected to range from $\frac{x}{2.8}$ to 2.8x.

D.4 SCREENING QUALITY ASSURANCE AUDITS

As a quality assurance check on the screening process, approximately five percent of the sources were independently screened by a second screener. Figure D-19 compares the screening values obtained by both screeners at the Chevron and Powerine refineries. This plot indicates good agreement of screening values between screeners with no apparent high or low bias by either screener. There were only two cases of disagreement on whether or not a source was screening greater than or equal to 10,000 ppmv.

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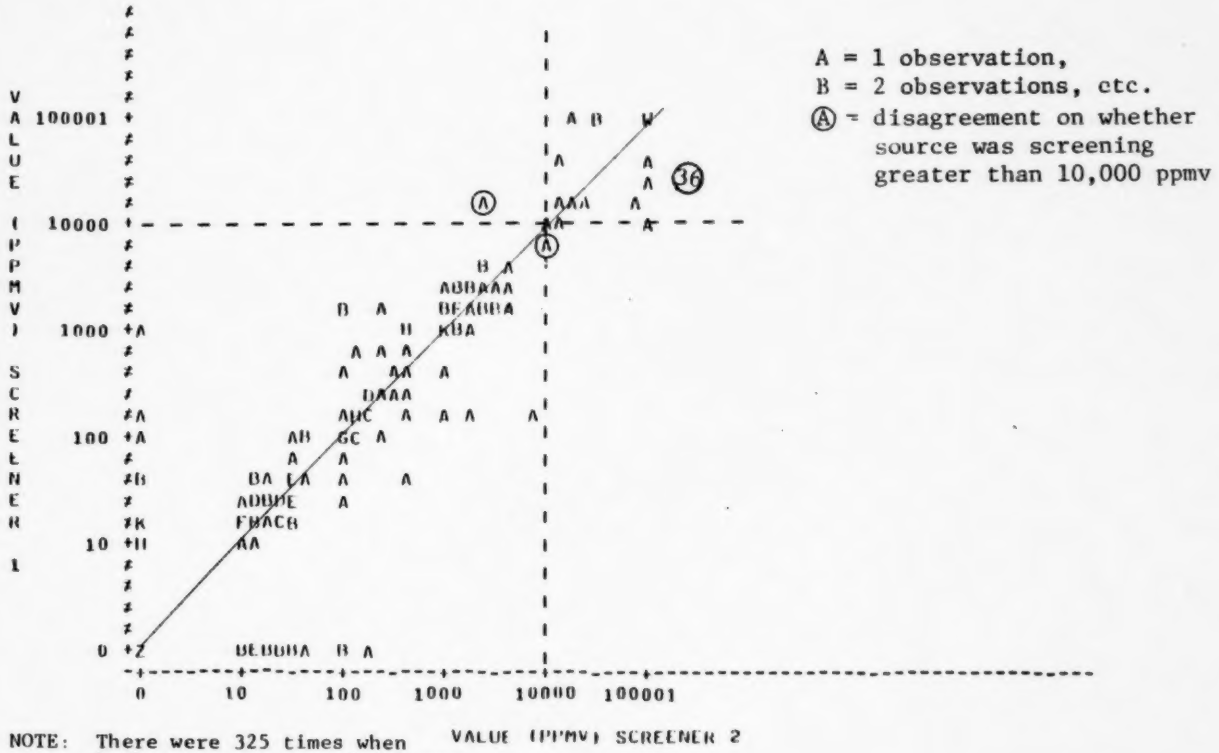
*Variance multiplier = $10^{1.96(0.23)}$



NOTE: There were 325 times when both screeners recorded 0 ppmv

FIGURE D-19
QUALITY ASSURANCE CHECK
COMPARISON OF VALUES OF SOURCES SCREENED BY TWO SCREENERS

APPENDIX E

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
CPB02	400	02/25/81					
CPB04	500	08/07/78	02/26/81				
CPB05	Missing	12/08/77	11/16/78	11/30/78	02/07/79	02/26/81	
CPB06	Missing	08/16/77	12/08/77	02/22/78	10/31/78	02/06/79	02/26/81
CPB07	90	03/07/77	12/09/77	02/11/79	02/26/81		
CPB1A	0	01/03/77 04/15/80	12/08/77 02/26/81	01/27/78	02/07/79	05/23/79	03/06/80
CPB10	30	12/14/77	11/18/80				
CPB11	75	02/27/81					
CPB12	250	11/02/77	04/23/80	02/27/81			
CPB3A	1500	12/04/75	02/23/81				
CPB8A	0	01/05/77	02/09/79	03/05/81			
CP100	0	09/08/77 01/21/80	09/30/77 05/05/80	03/07/78 06/25/80	04/11/78 01/12/81	05/01/79 03/03/81	07/20/79
CP100B	Missing	04/15/77 01/21/80	11/14/77 03/01/80	01/20/78	03/01/78	03/03/78	09/16/79

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
CP102B	Missing	02/14/77	03/15/77	06/07/77	08/12/77	09/28/77	Missing
		02/04/78	05/08/79	03/06/80			
CP103	150	04/11/78	02/28/80				
CP104	500	04/11/78	02/25/80				
CP104A	0	04/12/78	02/28/80				
CP108	0	04/10/78	02/28/80				
CP109A	Missing	04/11/78	02/28/80				
CP110	70	02/27/80					
CP112	100	04/12/78	11/02/78	11/07/79	02/14/80	02/27/80	
VP1	0	01/07/77	03/21/77	02/16/78	07/21/78	02/25/79	02/27/79
		10/05/79	02/04/81				
VP4A	Missing	01/11/77	07/19/78	11/06/79	11/30/79	03/31/80	10/13/80
VP5	0	03/17/77	02/17/78	06/26/78	04/12/79	05/03/80	12/15/80
		12/29/80	02/06/81				
VP6	0	07/21/78					
VP6A	Missing	07/17/78					
3PP1	4500	05/01/79					

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
3PP2A	1800	03/26/77	04/28/79	01/22/80	09/26/80	10/13/81	02/02/81
P22F	0	Missing	12/22/80	Missing	Missing	02/11/81	
P22AF	0	03/20/80					
P4	100	10/01/70	03/18/71	02/12/73	09/28/75	07/12/77	11/01/77
P5	200	01/25/72	Missing	11/14/77	09/07/78	08/07/79	01/23/80
P3	5000	11/04/70	03/16/71	11/30/71	07/01/74	03/17/75	02/05/76
		07/14/76	11/07/77	03/10/80			
P29	0	03/20/74	11/26/74	01/16/75	09/26/75	11/14/75	07/29/77
P191	0	05/08/67	10/09/68	12/16/71	09/18/72	01/23/73	10/18/73
		11/07/73	Missing	Missing	Missing	01/16/78	01/09/79
P191A	0	07/09/73	09/23/73	06/03/76	03/02/78	04/06/78	09/27/78
		06/08/79	01/07/80				
P190	30	01/07/71	01/11/72	01/17/72	Missing	11/03/76	11/04/76
		01/22/77	Missing	02/08/78	06/27/78	06/30/78	04/30/80
		05/08/80	09/29/80				
P180	900	09/07/65	02/15/73	12/03/75	04/08/76	11/16/76	11/17/77
		05/30/78					
P710B	30,000	08/13/74					

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
P1A	100,001	05/17/62	01/09/72	04/17/72	07/04/72	05/04/73	06/15/73
		10/30/75	02/09/76	10/11/77	05/30/78	07/14/78	01/11/79
P1	0	09/09/71	03/12/73	07/24/73	02/23/76	02/26/76	04/09/79
		09/04/80	10/15/80				
P317	0	03/23/71	04/27/73	12/10/73	04/18/74	10/30/74	01/21/76
		Missing	Missing	Missing	Missing	Missing	Missing
		09/01/76	08/25/77				
P14A	4000	09/01/65	02/19/70	02/01/71	09/29/72	03/19/73	04/23/74
		07/24/74	12/10/74	08/26/80	Missing	Missing	Missing
		01/28/81					
P260A	0	05/16/65	09/23/65	08/17/71	11/01/71	02/09/72	01/08/73
		01/16/79	03/08/79				
P105	0	12/20/78	12/28/78	10/25/79			
P220	0	03/11/70	04/19/71	12/12/71	11/08/73	07/22/74	04/26/76
		03/08/79	07/03/79	09/02/80			
P143	8000	Missing	02/10/78	03/03/78			
P143A	200	04/05/78	02/07/80				
P142	3000	10/14/78					
P101	700	12/12/73					
P10	200	10/10/72	03/19/73	12/05/74	11/21/75	07/06/77	09/08/77
		03/29/78	04/21/78	04/03/79			

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
P700A	100	01/21/80					
P720	20,000	07/18/72	01/02/73	05/02/75	05/19/77	09/15/77	Missing
		09/15/78	11/03/80				
P720A	20	08/21/72	Missing	Missing	Missing	04/01/80	
P730	200	05/22/72	09/18/78				
P736	Missing	Missing	07/18/77	Missing	07/13/77		
P736A	Missing	05/24/72	04/09/75	07/02/75	10/10/75	08/30/76	03/23/77
		03/25/77	04/13/77	04/21/77	06/30/78	03/02/81	
P750	150	02/10/73	01/07/76	06/05/78	08/08/79		
P750A	0	08/18/70	08/08/72	08/15/73	08/19/74	06/26/76	01/21/77
		08/22/78	07/31/79				
P753	30,000	12/05/77					
P753A	100,000	08/20/69	06/19/79				
P760	0	02/26/70	04/06/72	11/14/72	11/16/72	09/11/73	04/10/76
		04/15/76	01/17/78				
P760A	30,000	01/23/78	06/27/78				
P771	200	Missing	Missing	01/26/73	07/07/75	03/06/80	

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
P771A	100	04/02/70	05/09/73	01/10/75	02/27/78	08/02/78	Missing
		01/25/80					
P772	0	08/20/69	02/26/70	04/06/72	11/09/72	11/16/72	11/29/72
		09/11/73	04/10/76	04/15/76	01/17/78		
PK501	Missing	03/02/70	12/01/70	01/06/71	03/23/71	05/12/71	01/04/72
		01/28/72	02/04/72	02/11/72	02/14/72	07/31/75	04/04/77
		05/15/79					
P502A	Missing	11/30/79					
P502B	Missing	04/07/70	05/14/73	12/26/73	01/31/75		
P502D	Missing	06/06/77					
P503A	Missing	12/20/71					
P503C	Missing	12/19/71					
P503B	Missing	12/07/73	03/21/77				
P522	Missing	09/12/77					
P522A	Missing	04/16/75					
P601	Missing	11/25/70	09/05/72				
P603A	Missing	10/02/78					
P603C	Missing	03/28/74					

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
P603B	Missing	10/24/73	04/23/74				
P603D	Missing	12/12/73					
P620	Missing	03/06/75					
P622A	Missing	05/24/73	12/09/74				
P623	Missing	02/18/75					
P623A	Missing	11/20/70	09/13/77				
P780	500	01/08/80					
P64	0	04/23/74	07/01/74	06/19/75	12/27/75	01/05/76	01/15/76
		05/28/76	Missing	Missing	Missing	Missing	Missing
		10/25/77	11/27/78	11/27/79			
P710	1500	05/03/78					
P172	15,000	05/03/77	10/27/80				
P99	1200	06/16/76					
P160A	20	10/12/80	01/24/81				
P141	20,000	07/02/80					
P141A	200	11/13/80					
P47	200	08/02/65	07/07/70	07/17/70	03/14/74	10/13/75	11/05/75
		04/11/77					

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
P25	0	05/28/65	11/25/70	06/18/71	09/03/71	10/08/71	01/23/73
		05/11/73	09/27/73	02/14/74	04/10/74	11/25/74	07/21/76
		09/28/76	05/17/77	04/13/78	02/12/79		
P26	10	04/15/71	06/18/71	09/03/71	10/08/71	01/05/72	01/07/72
		01/03/73	04/17/73	02/14/74	03/21/74	05/20/74	Missing
		09/24/75	04/01/76	05/17/77	11/28/77	03/13/78	02/12/79
		03/27/79	01/08/80				
P50	0	11/07/65	05/19/71	06/21/71	11/03/71	12/16/71	09/14/72
		10/16/72	11/21/72	01/16/73	03/07/73	06/29/73	08/08/75
		05/17/77	Missing	06/17/80	12/16/80		
P49	0	09/23/65	11/07/65	05/08/70	08/25/70	01/20/71	05/19/71
		06/21/71	11/03/71	12/16/71	02/21/73	06/04/73	11/28/73
		02/14/74	06/04/74	06/05/75	03/08/76	05/17/77	02/12/79
P39	700	04/24/73	05/10/73	05/16/73	01/11/74	03/19/74	04/01/74
		06/09/76	12/15/76	06/30/77	09/29/77	10/03/77	10/05/77
		10/06/77	10/17/77	07/06/78	08/02/78	09/20/78	09/22/78
		09/28/78	10/16/78	11/13/78	02/13/79	04/09/79	
P8A	100,001	11/21/74					
P6	100	08/31/73	03/11/74	04/08/74	04/12/74	04/15/74	05/14/74
		01/02/75	03/06/75	10/03/75	08/23/76	12/13/78	
P45	0	02/01/73	03/20/78	05/17/78	01/30/79	03/21/80	
P44	30,000	03/25/74	01/13/81				

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
P6A	50	12/18/69	08/16/71	08/18/71	05/08/73	03/13/74	04/05/74
		04/12/74	08/26/76	Missing	08/30/76	09/02/74	
P8	40	06/07/73	11/23/73	Missing	Missing	07/06/77	
P9	0	08/10/73	01/08/77	11/21/77			
P14	70,000	03/07/73	03/01/76	07/07/76			
P15	100	04/06/71	01/03/73	03/13/73	10/29/73	07/15/74	08/02/74
		02/02/78	04/14/78				
P15A	0	Missing	10/01/74	03/30/76	07/22/77	09/15/77	Missing
		02/04/81					
P21	0	10/12/65	06/14/71	03/09/73	10/02/73	03/26/74	03/08/76
P21A	2000	01/14/72					
P22	5000	11/26/65	10/06/66	09/27/68	12/30/68	01/06/69	11/18/69
		01/02/71	Missing	Missing	09/27/76	08/01/78	
P23	70	12/02/69	01/28/70	07/24/73	03/15/76	05/29/79	
P23A	0	03/15/76	02/09/79				
P27A	0	03/07/78					
P30	4000	01/04/72	12/01/72	03/01/73	11/08/73	01/14/74	
P36	20,000	09/24/74					

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
P36A	0	09/10/65	09/23/71	04/30/73	09/09/75	03/01/76	
P39A	30,000	03/28/74					
P43A	300	07/24/78	12/05/78	01/03/79	01/29/79	04/11/79	10/18/79
P43	20	04/10/73	04/08/74	10/14/74	Missing	02/09/76	05/17/77
		07/07/78	02/20/79	Missing	Missing	Missing	07/10/80
		10/28/80	11/20/80				
P46A	2000	11/15/65	08/12/70	08/19/70	10/14/71	01/23/73	03/08/73
		08/28/74	08/13/76	10/14/76	10/15/76	04/27/78	11/13/78
		03/26/79	02/06/80				
P67	3000	09/21/78	Missing	01/16/79			
P62	Missing	Missing	12/28/71	08/29/72	01/03/73	Missing	05/23/74
		Missing	08/25/75	01/14/76	06/15/76	07/27/76	10/21/76
		12/22/76	05/17/77	Missing	Missing	Missing	Missing
		06/06/78	11/29/78	10/13/80			
P63	Missing	04/27/65	04/29/70	03/11/71	02/09/72	02/08/73	07/24/73
		04/15/74	07/14/74	10/23/74	02/04/75	09/04/75	04/14/76
		10/18/76	12/20/76	05/17/77	Missing	Missing	Missing
		06/06/78					
P100	0	05/24/65	04/01/75	09/27/79			
P100A	0	07/27/70	08/30/76	10/07/76	10/18/77	01/10/80	
P101A	0	02/15/78	07/28/80				

LIST OF PUMPS WITH SCREENING VALUES AND DATES OF PUMP SEAL FAILURES

Pump	Screening Value	Dates of Failure					
P104B	0	01/26/81					
P110	300	03/07/78					
P140	900	06/17/80					
P140A	0	08/07/78					
P161	3000	09/27/76	02/15/79	01/06/81			
P170	Missing	05/10/70	08/01/74	08/07/74	10/16/78	03/08/79	04/19/79
		08/07/79	11/01/79				
P170A	0	04/08/68	05/16/70	08/14/70	05/11/71	05/23/74	Missing
		Missing	Missing	Missing	04/08/78	08/01/79	11/28/79
		12/10/79	12/11/79	01/10/80			
P171	3500	02/09/70	06/16/70	04/19/71	01/27/72	05/01/72	11/14/73
		12/10/73	12/19/73	04/01/74	04/28/74	07/14/74	10/07/74
		04/08/75	10/08/76	10/15/76	10/19/76	06/23/77	06/24/77
		07/27/77	08/25/77	10/17/77	02/10/78	02/21/78	04/05/78
		04/26/78	04/28/78	04/30/78	05/01/78	05/02/78	10/30/78
		12/15/78	01/09/79	10/31/79	11/27/79		
P254	0	01/05/72	Missing	10/17/79	01/09/81		
P260	0	08/23/65	10/08/70	05/06/75	09/07/77	12/06/78	04/16/80

APPENDIX F

CHANGES AND CORRECTIONS TO SCREENING DATA SHEETS

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
ID (Source Identification)	ID=1 (3/6/81)	ID=100001	Duplicate source ID
	2 (3/6/81)	100002	Duplicate source ID
	3 (3/6/81)	100003	Duplicate source ID
	4 (3/6/81)	100004	Duplicate source ID
	566 (and VALUE=7000)	567	Miscoded sequence
	806 (and VALUE=300)	804	Miscoded sequence
	075 (541st record)	100975	Duplicate source ID
	1500 (755th record	101500	Duplicate source ID
	3466 (and VALUE=0)	13466	Duplicate source ID
	3467 (4617th record)	13467	Duplicate source ID
	3627 (and TYPE=3)	3628	Miscoded sequence
	3965 (and VALUE=500)	13965	Duplicate source ID
	3966 (and VALUE=50)	13966	Duplicate source ID
	3967 (and TYPE=15)	13967	Duplicate source ID
	4035 (5670th record)	14035	Duplicate source ID
	4257 (and VALUE=0)	14257	Duplicate source ID
	4970-5000	34970-35000	Duplicate source IDs
	6050 (and TYPE=10)	6048	Miscoded sequence
	6396 (4149th record)	16396	Duplicate source ID
	6397 (and VALUE=2000)	6387	Miscoded sequence
	6398 (and VALUE=5000)	6388	Miscoded sequence
	6399 (and VALUE=0)	6389	Miscoded sequence
	6425 (and VALUE=0)	6416	Miscoded sequence
	6426 (and VALUE=0)	6417	Miscoded sequence
	6427 (and VALUE=700)	6418	Miscoded sequence
	6428 (and VALUE=10)	6419	Miscoded sequence
	6429 (and VALUE=0)	6420	Miscoded sequence
	6430 (and VALUE=0)	6421	Miscoded sequence
	6431 (and VALUE=0)	6422	Miscoded sequence

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
ID (Source Identification)	ID=6432 (and VALUE=0)	ID=6423	Miscoded sequence
	7310-7469 (3/3/81)	37310-37469	Duplicate source IDs
	8180-8189 (3/2/81)	28180 28189	Duplicate source IDs
	7480-8363 (3/4/81)	17480-18363	Duplicate source IDs
	8001-8179 (3/3/81)	38001-38179	Duplicate source IDs
SDATE (Sample Date)	SDATE=21281	SDATE=020281	Recording error
	21381	021381	Recording error
	22081	022081	Recording error
	22381	022381	Recording error
	22481	022481	Recording error
	22581	022581	Recording error
	22681	022681	Recording error
	3 481	030481	Recording error
	3 581	030581	Recording error
	30581	030581	Recording error
	3 81	030681	Recording error
	3 681	030681	Recording error
	30681	030681	Recording error
FACILITY (Plant)	All records	FACILITY=1	Some facility numbers not recorded
INSTRM (Instrument Number)	INSTRM=2	INSTRM=62	'6' not recorded
	INSTRM=5	65	'6' not recorded
	INSTRM=Missing	63	Not recorded

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
INSTRM (Instrument Number)	ID=8660-8669	INSTRM=63	Miscoded
UNIT (Process Unit)	UNIT=62	UNIT=2	Miscoded
	UNIT=1 and SDATE=022481	20	Miscoded
TYPE (Source Type)	ID=2253	TYPE=6	Miscoded
	2254-2259	4	Miscoded
	2260	6	Miscoded
	2261-2266	4	Miscoded
	2267	6	Miscoded
	2268-2272	4	Miscoded
	2273-2275	6	Miscoded
	2276-2284	4	Miscoded
	2285-2286	6	Miscoded
	2287-2289	4	Miscoded
	2290	6	Miscoded
	2291-2295	4	Miscoded
	2296	66	Miscoded
SERVICE (Stream Service)	TYPE=6	SERVICE=9	Miscoded
	ID=1326	3	Not recorded
	1578	3	Not recorded
	2254-2257	5	Miscoded
	2258-2259	3	Miscoded
	2261	3	Miscoded
	2262-2266	5	Miscoded
	2268-2272	5	Miscoded
	2276-2281	3	Miscoded
	2282	5	Miscoded

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
SERVICE (Stream Service)	ID=2283-2284	SERVICE=3	Miscoded
	2287-2289	3	Miscoded
	2291-2295	3	Miscoded
	3672	3	Miscoded
	3992	1	Miscoded
	4082-4083	3	Miscoded
	5446-5449	3	Miscoded
	6009	3	Miscoded
	6450-6451	1	Miscoded
	6297	3	Miscoded
	8011-8012	3	Miscoded
	17558-17559	3	Miscoded
	18216	3	Miscoded
MAT1 (Primary Material in Line)	ID=2254	MAT1=530	Miscoded
	2255-2257	520	Miscoded
	2258-2259	510	Miscoded
	2261	520	Miscoded
	2262-2265	530	Miscoded
	2266	520	Miscoded
	2268-2272	520	Miscoded
	2276	550	Miscoded
	2277	510	Miscoded
	2278	550	Miscoded
	2279-2280	507	Miscoded
	2281	550	Miscoded
	2282	530	Miscoded
	2283-2284	550	Miscoded
	2287	530	Miscoded
	2288	550	Miscoded
	2289	507	Miscoded
	2291-2295	550	Miscoded

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
MAT1 (Primary Material in Line)	ID=4082-4083	MAT1=503	Miscoded
	6450-6451	001	Miscoded
	8011-8012	503	Miscoded
	17558-17559	503	Miscoded
	18216	503	Miscoded
	100001-100003	503	Miscoded
	TYPE=6	999	All washup drains have unknown material
CONC1 (Concentration of Primary Material)	ID=21-30	CONC1=9	Not recorded
	859	9	Not recorded
	2255-2259	9	Miscoded
	2261-2266	9	Miscoded
	2276-2284	9	Miscoded
	2287-2289	9	Miscoded
	2291-2295	9	Miscoded
	6450-6451	9	Miscoded
	18216	9	Miscoded
MAT2 (Secondary Material in Line)	ID=100001-100003	MAT2=620	Miscoded
COM3 (Comment code)	ID=6177	COM3=1	Not keypunched
	6180	1	Not keypunched
	8819-8827	1	Not keypunched
	8829-8842	1	Not keypunched
	100004	1	Not keypunched
	2913-2914	2	Not keypunched

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
COM3 (Comment Code)	ID=2922-2923	COM3=2	Not keypunched
	3644-3650	2	Not keypunched
	2941-2946	2	Not keypunched
	17672-17674	2	Not keypunched
	2959-2966	2	Not keypunched
	3655-3660	2	Not keypunched
	3667-3672	2	Not keypunched
	17610-17619	2	Not keypunched
	2970-2971	2	Not keypunched
	3676-3690	2	Not keypunched
	17710-17712	2	Not keypunched
	2974-2976	2	Not keypunched
	3760-3761	2	Not keypunched
	3776-3777	2	Not keypunched
	8454-8455	2	Not keypunched
	2986-2989	2	Not keypunched
	3835-3839	2	Not keypunched
	8552-8555	2	Not keypunched
	3869-3874	2	Not keypunched
	7887-7889	2	Not keypunched
	2996-2997	2	Not keypunched
	3881-3882	2	Not keypunched
	7896-7897	2	Not keypunched
	2999-3000	2	Not keypunched
	6072-6073	2	Not keypunched
	8190	2	Not keypunched
	8212	2	Not keypunched
	6233-6236	2	Not keypunched
	8571-8591	2	Not keypunched
	5001	2	Not keypunched
	5010-5015	2	Not keypunched
	4077-4078	2	Not keypunched
	8663-8668	2	Not keypunched

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
COM3 (Comment Code)	ID=5042-5047	COM3=2	Not keypunched
	4082-4083	2	Not keypunched
	5053	2	Not keypunched
	5098-5103	2	Not keypunched
	3995-3996	2	Not keypunched
	4112	2	Not keypunched
	4290	2	Not keypunched
	5448-5450	2	Not keypunched
	3403-3404	2	Not keypunched
	5519-5527	2	Not keypunched
	3384	2	Not keypunched
	3322	2	Not keypunched
	5529-5554	2	Not keypunched
	3326-3330	2	Not keypunched
	5594	2	Not keypunched
	2834	2	Not keypunched
	3179-3182	2	Not keypunched
	2828-2829	2	Not keypunched
	2799-2803	2	Not keypunched
	2786-2791	2	Not keypunched
	2779	2	Not keypunched
	2785	2	Not keypunched
	2579	2	Not keypunched
	4591-4592	2	Not keypunched
	4289	2	Not keypunched
	6098-6099	2	Not keypunched
	2589-2590	2	Not keypunched
	6098-6099	2	Not keypunched
	2706-2715	2	Not keypunched
	5163-5164	3	Not keypunched
	3519-3520	3	Not keypunched
	3532	3	Not keypunched
	3550-3556	3	Not keypunched

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
COM3 (Comment Code)	ID=3603	COM3=3	Not keypunched
	17669-17671	3	Not keypunched
	8117-8119	3	Not keypunched
	8281-8300	3	Not keypunched
	17675-17676	3	Not keypunched
	8637	3	Not keypunched
	8692	3	Not keypunched
	18132	3	Not keypunched
	8756	3	Not keypunched
	8771	3	Not keypunched
	8814	3	Not keypunched
	18331-18334	3	Not keypunched
	5431-5434	3	Not keypunched
	17558	3	Not keypunched
	5656	3	Not keypunched
	17559	3	Not keypunched
	18241-18243	3	Not keypunched
	18198-18199	3	Not keypunched
	3615	3	Not keypunched
	3623-3625	3	Not keypunched
	5431-5434	3	Not keypunched
	5689-5693	3	Not keypunched
	17559	3	Not keypunched
	18241-18243	3	Not keypunched
	6367-6368	3	Not keypunched
	18198-18199	3	Not keypunched
	18172	3	Not keypunched
	18174	3	Not keypunched
	3666	3	Not keypunched
	5170	3	Not keypunched
	18162-18165	3	Not keypunched
	18122-18123	3	Not keypunched
	5185-5187	3	Not keypunched

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
COM3 (Comment Code)	ID=5358-5359	COM3=3	Not keypunched
	8506-8508	3	Not keypunched
	3401-3402	3	Not keypunched
	8533-8534	3	Not keypunched
	3341	3	Not keypunched
	3201	3	Not keypunched
	8535	3	Not keypunched
	8537-8539	3	Not keypunched
	7840-7850	3	Not keypunched
	8004-8009	3	Not keypunched
	8011-8012	3	Not keypunched
	8021-8028	3	Not keypunched
	8090-8092	3	Not keypunched
	8101-8104	3	Not keypunched
	3661-3662	3	Not keypunched
	8010	7	Not keypunched
	5290	9	Not keypunched
	4014	9	Not keypunched
TAG (Maintenance Tag Number or Pump Number)	TAG=787	TAG=0787	Miscoded
	MP143	P143	To match other files
	P161	P161	To match other files
	MP36	P36	To match other files
	MP501	P501	To match other files
	ID=4014	P736	Not recorded in proper column
	TAG=1012 and VALUE=900	1013	Keypunch error
	ID=8654	0980	Not keypunched
	28188	0669	Not keypunched
	28189	0668	Not keypunched

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
TAG (Maintenance Tag Number or Pump Number	ID=8151	TAG=0983	Not keypunched
	1162	P5	Miscoded
	1163	P3	Miscoded
	3915	P22AF	Duplicate tags
	3914	P22F	Duplicate tags
VALUE2 (Post Maintenance Value)	TAG=0534	VALUE=2	Value acquired later
	0535	70	Value acquired later
	0536	200	Value acquired later
	0522	2000	Value acquired later
	0530	1000	Value acquired later
	0540	500	Value acquired later
	0532	20	Value acquired later
	0921	70	Value acquired later
	0920	200	Value acquired later
	0957	200	Value acquired later
	0992	20	Value acquired later
	0993	800	Value acquired later
	0994	500	Value acquired later
	0967	100	Value acquired later
	0995	10	Value acquired later
	0971	1000	Value acquired later
	0996	5	Value acquired later
	0968	1000	Value acquired later
	0997	200	Value acquired later
	0970	1000	Value acquired later
	0972	1000	Value acquired later
	0692	20	Value acquired later
	0973	100	Value acquired later

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
VALUE2 (Post Maintenance Value)	TAG=0974	VALUE2=300	Value acquired later
	0975	30	Value acquired later
	0976	1000	Value acquired later
	0977	1000	Value acquired later
	0978	100	Value acquired later
	0979	100	Value acquired later
	0980	150	Value acquired later
	0981	200	Value acquired later
	0982	3000	Value acquired later
	0983	2000	Value acquired later
	0984	200	Value acquired later
	0985	700	Value acquired later
	0986	400	Value acquired later
	0987	0	Value acquired later
	0988	300	Value acquired later
	0989	6000	Value acquired later
	0990	50	Value acquired later
	0991	100	Value acquired later
	0669	4000	Value acquired later
	0668	2000	Value acquired later
	0983	2000	Value acquired later
	0473	70	Value acquired later
	0518	1000	Value acquired later
	0505	1000	Value acquired later
	0510	5000	Value acquired later
	0509	2000	Value acquired later
	0512	1000	Value acquired later
	1043	300	Value acquired later
	1045	1000	Value acquired later
	1047	500	Value acquired later
	1048	3000	Value acquired later
	1050	200	Value acquired later
	1061	200	Value acquired later

Changes to Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
VALUE2 (Post Maintenance Value)	TAG=1032	VALUE2=700	Value acquired later
	1033	300	Value acquired later
	1034	30	Value acquired later
	1035	4000	Value acquired later
	1036	20	Value acquired later
	1037	50	Value acquired later
	1038	300	Value acquired later
	1039	1000	Value acquired later
	1040	10	Value acquired later
	1041	20	Value acquired later
	1042	70	Value acquired later
	1046	3000	Value acquired later
	1049	100	Value acquired later
	1060	500	Value acquired later
	0511	300	Value acquired later
	ID=8654	50	Value acquired later
Delete Record	ID=7748		Pump screened twice
	3909		Pump screened twice
	3912		Pump screened twice
	5991		Pump screened twice
	4013		Not screened

Changes to Screening Data - Powerine

Variable Changed	Source Identification	New Value	Reason
ID (Source ID)	ID=1366 and TYPE=10	ID=1365	Duplicate source ID
	689th record	2279	Duplicate source ID
	ID=3009 and TYPE=6	3010	Duplicate source ID
	2005th record	13606	Duplicate source ID
FACILITY (Plant)	ID=2041-2050	FACILITY=2	Not recorded
SERVICE (Stream Service)	TYPE=6	SERVICE=9	Service unknown in open washup drains
TYPE (Source Type)	ID=4069	TYPE=4	Miscoded
	2623	4	Miscoded
	2993	4	Miscoded
	3010	4	Miscoded
	3055	4	Miscoded
	3079	4	Miscoded
	3091	4	Miscoded
	3118	4	Miscoded
	3144	4	Miscoded
	3468	4	Miscoded
	3489	4	Miscoded
	3509	4	Miscoded
	3559	4	Miscoded
	3602	4	Miscoded
	1187	4	Miscoded
	1196	4	Miscoded
	1346	4	Miscoded
	1347	4	Miscoded

Changes to Screening Data - Powerine

Variable Changed	Source Identification	New Value	Reason
TYPE (Source Type)	ID=1406	TYPE=4	Miscoded
	9006	4	Miscoded
	9077	4	Miscoded
	9085	4	Miscoded
	9122	4	Miscoded
	9149	4	Miscoded
	9165	4	Miscoded
	9184	4	Miscoded
	9193	4	Miscoded
	9215	4	Miscoded
	9255	4	Miscoded
	9370	4	Miscoded
	9425	4	Miscoded
	9495	4	Miscoded
VALUE (Screening Value)	VALUE=3	VALUE= Missing	Miscoded
MAT1 (Primary Material in Line)	ID=5093-5096	MAT1=501	Miscoded
	5098-5106	501	Miscoded
	TYPE=6	999	Material unknown in open washup drains
CONC1 (Concentration of Primary Material)	TYPE=6	CONC1= Missing	Concentration unknown in open washup drain
COM1 (Comment Code)	ID=9380	COM1=3	Miscoded

Changes to Screening Data - Powerine

Variable Changed	Source Identification	New Value	Reason
TAG (Pump or compressor number)	ID=4120	TAG=2PP2	Miscoded
	2720	CP104A	Miscoded
	2053	CP100B	Miscoded
	2054	' '	Miscoded
	5056	VRC1B	Miscoded
Delete Records	SERVICE=Missing		Water Lines

Changes to Distance Screening Data - Chevron

Variable Changed	Source Identification	New Value	Reason
DIST (Screening Value at 0 cm.)	ID=100003	DIST=25000	Keypunch error
SDATE (Sample	SDATE=21381	SDATE=021381	Miscoded
	21481	021481	Miscoded
	22581	022581	Miscoded
	3 681	030681	Miscoded
	3 481	030481	Miscoded
	22481	022481	Miscoded
UNIT (Process Unit Number)	UNIT=62	UNIT=2	Miscoded
ID	SDATE=030481	ID=ID +10000	Duplicate source IDs
TAG (Pump Number)	TAG=MP36	TAG=P36	For matching purposes
	MP143	P143	For matching purposes
	MP161	P161	For matching purposes

Changes to Distance Screening Data - Powerine

Variable Changed	Source Identification	New Value	Reason
DIST1 (Screening Value at 1 cm.)	All records on 3/21/81 and DIST1 <1000	DIST1= DIST1 - 100	Background screening value = 100
DIST25 (Screening Value at 2.5 cm.)	All records on 3/21/81 and DIST25 <1000	DIST25= DIST25 - 100	Background screening value = 100
DIST5 (Screening Value at 5 cm.)	All records on 3/21/81 and DIST5 <1000	DIST5= DIST5 - 100	Background screening value = 100
DIST10 (Screening Value at 10 cm.)	All records on 3/21/81 and DIST10 <1000	DIST10= DIST10 - 100	Background screening value = 100
DIST20 (Screening Value at 20 cm.)	All records on 3/21/81 and DIST20 <1000 ID=4203	DIST20= DIST20 - 100 DIST20=100001	Background screening value = 100 Miscoded
TAG (Pump or Compressor Number)	ID=5056	TAG=VRC1B	Miscoded

Changes to Pump Seal Failure Records - Chevron

Variable Changed	Source Identification	New Value	Reason
FAIL15 (Date of 15th Failure)	TAG=P49	FAIL15= 6/5/75	Refinery miscoding
REASON15 (Failure Reason Code)	P49	REASON15=G	Refinery miscoding
FAIL16 (Date of 16th Failure)	P49	FAIL16= 3/8/76	Refinery miscoding
REASON16 (Failure Reason Code)	P49	REASON16=G	Refinery miscoding
FAIL17 (Date of 17th Failure)	P49	FAIL17= 5/17/77	Refinery miscoding
REASON17 (Failure Reason Code)	P49	REASON17=G	Refinery miscoding
FAIL18 (Date of 18th Failure)	P49	FAIL18= 2/12/79	Refinery miscoding

Changes to Pump Seal Failure Records - Chevron

Variable Changed	Source Identification	New Value	Reason
REASON18 (Failure Reason Code)	TAG=P49	REASON18=CF	Refinery miscoding
FAIL9 (Date of 9th Failure)	P49	FAIL9= 12/16/71	Refinery miscoding
REASON9 (Failure Reason Code)	P49	REASON9=G	Refinery miscoding
FAIL10 (Date of 10th Failure)	P49	FAIL10= 2/21/73	Refinery miscoding
REASON10 (Failure Reason Code)	P49	REASON10=G	Refinery miscoding
FAIL11 (Date of 11th Failure)	P49	FAIL11= 6/4/73	Refinery miscoding
REASON11 (Failure Reason Code)	P49	REASON11=AB	Refinery miscoding

Changes to Pump Seal Failure Records - Chevron

Variable Changed	Source Identification	New Value	Reason
FAIL12 (Date of 12th Failure)	TAG=P49	FAIL12= 11/25/73	Refinery miscoding
REASON12 (Failure Reason Code)	P49	REASON12=AB	Refinery miscoding
FAIL13 (Date of 13th Failure	P49	FAIL13= 2/14/74	Refinery miscoding
REASON13 (Failure Reason Code)	P49	REASON13=B	Refinery miscoding
FAIL14 (Date of 14th Failure)	P49	FAIL14= 6/4/74	Refinery miscoding
REASON14 (Failure Reason Code)	P49	REASON14=G	Refinery miscoding
REASON21 (Failure Reason Code)	P39	REASON21= 1KFB	Refinery miscoding

Changes to Pump Seal Failure Records - Chevron

Variable Changed	Source Identification	New Value	Reason
FAIL22 (Date of 22nd Failure)	TAG=P39	FAIL22= FAIL23	Refinery miscoding
REASON22 (Failure Reason code)	P39	REASON22= REASON23	Refinery miscoding
FAIL23 (Date of 23rd Failure)	P39	FAIL23= FAIL25	Refinery miscoding
REASON23 (Failure Reason Code)	P39	REASON23= REASON25	Refinery miscoding
FAIL24 (Date of 24th Failure)	P39	FAIL24= Missing	Refinery miscoding
REASON24 (Failure Reason Code)	P39	REASON24= Missing	Refinery miscoding
FAIL25 (Date of 25th Failure)	P39	FAIL25= Missing	Refinery miscoding

Changes to Pump Seal Failure Records - Chevron

Variable Changed	Source Identification	New Value	Reason
REASON25 (Failure Reason Code)	TAG=P39	REASON25= Missing	Refinery miscoding
TAG (Pump Tag Number)	ATAG=1166 and TAG=P22 ATAG=1167 and TAG=P22A	TAG=P22F TAG=P22AF	Duplicate pump TAGS Duplicate pump TAGS
FAIL5 (Date of 5th Failure)	TAG=P30	FAIL5= 11/14/74	Refinery miscoding
FAIL4 (Date of 4th Failure)	TAG=P43	FAIL4= Missing	Refinery miscoding
REASON4 (Failure Reason Code)	TAG=P43	REASON4= Missing	Refinery miscoding
FAIL2 (Date of 2nd Failure)	TAG=P160A	FAIL2= 1/24/81	Refinery miscoding

Changes to Quality Control Data - Repeated Screenings - Powerine

Variable Changed	Source Identification	New Value	Reason
SDATE (Sample Date)	SDATE=3 481	SDATE=030481	Miscoded
	SDATE=3 681	030681	Miscoded
QC (Quality Control Code)	QC=Missing	QC=9	Not recorded

Changes to Quality Control Data - Repeated Screenings - Chevron

Variable Changed	Source Identification	New Value	Reason
SDATE (Sample Date)	SDATE=21381	SDATE=021381	Miscoded
	21781	021781	Miscoded
	21881	021881	Miscoded
	21981	021981	Miscoded
	22081	022081	Miscoded
	22381	022381	Miscoded
	22481	022481	Miscoded
	22581	022581	Miscoded
	22681	022681	Miscoded
	22781	022781	Miscoded
	30281	030281	Miscoded
	3 281	030281	Miscoded
	3 381	030381	Miscoded
	3 481	030481	Miscoded
	3 581	030581	Miscoded
	3 681	030681	Miscoded
INSTRM (Instrument Number)	INSTRM=6	INSTRM=62	Miscoded
	2	62	Miscoded
	3	63	Miscoded
	5	65	Miscoded

Changes to Quality Control Data - Replicate Screenings - Chevron

Variable Changed	Source Identification	New Value	Reason
ID (Source ID)	ID=8180-8189	ID=28180-28189	Duplicate source IDs
	SDATE=3/04/81	ID + 10000	Duplicate source IDs
	SDATE=3/03/81	ID + 30000	Duplicate source IDs
COM3 (Comment Code)	ID=18173	COM3=' '	Miscoded
VALUE (Screening Value)	ID=1111	VALUE=150	Keypunch error